

DOCUMENT RESUME

ED 231 332

IR 010 729

AUTHOR Charp, Sylvia; And Others
TITLE Layman's Guide to the Use of Computers in Education.
INSTITUTION Association for Educational Data Systems, Washington, D.C.
PUB DATE 82
NOTE 68p.
AVAILABLE FROM Association for Educational Data Systems, 1201 16th St., N.W., Washington, DC 20036 (\$4 ea., 10-99, \$3.50 ea., over 99, \$3 ea.).
PUB TYPE Guides - Non-Classroom Use (055) -- Information Analyses (070)
EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Automation; *Computer Assisted Instruction; *Computer Literacy; Computer Managed Instruction; *Computer Oriented Programs; *Computers; Data Processing; Glossaries; Management Information Systems; *Programming Languages
IDENTIFIERS Computer Simulation; *Computer Uses in Education

ABSTRACT

This book is designed to introduce educators to basic computing concepts, acquaint them with specific educational applications, and bridge the gap between technology in educational practice by interesting them in educational computing. A brief introduction and review of historical perspectives are followed by a description of computer applications in instruction. Specific topics addressed are computer literacy, computers as an instructional aid, computers as a subject of instruction, word processing, computer assisted instruction, computer managed instruction, information storage and retrieval, guidance and counseling, vocational education, other projects, and the future. The main components of a computer system are explained, including input, storage or memory, the control unit, arithmetic and logic unit, output, and microcomputers. A chapter on computer languages focuses on Assembler Language, COBOL, FORTRAN, PL/1, and BASIC. Administrative applications discussed are database management systems, management information systems, new administrative computer systems, software, the data processing center, advisory committee, development, operations, and maintenance. A discussion of office automation and an appendix containing computer term definitions complete the guide. (LMM)

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Layman's Guide to the Use of Computers in Education

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Printed by The University of Iowa Publications Department

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Layman's Guide to the Use of Computers in Education

This work was produced, in part, through a grant from
Digital Equipment Corporation.

PREFACE

The computer is a tool and, as with any such instrument, serves its user only as well as one is able to effectively employ it. Using the computer in schools is what this book is about. Hopefully, it will address several purposes: to introduce educators to certain fundamental computing concepts; to acquaint them with specific educational applications; and to spark their interest in educational computing by bridging the gap between technology and educational practice. Of course, no one book can fulfill any one of these. Perhaps it will, however, remove just a little of the mystery of the unknown about a fascinating and ever-expanding area.

The first edition of this book was published by AEDS in 1971. The popularity of the book never seemed to fade, thus prompting us to present this edition.

The authors wish to acknowledge the assistance of Robert Hall, Don McClain, Rex Thomas, and William Wise in the production and editing. They were most giving of their time and expertise.

The Association would also like to express its appreciation to Digital Equipment Corporation for financial support provided for the production of this work.

—William C. Bozeman
AEDS Publications Chair

Section 1

INTRODUCTION

Computers are having a profound effect on today's society as our lives are becoming more and more dependent upon electronic devices. We are being relieved of arduous mental tasks in the way that manual tasks were relieved by machinery many years ago.

Since the use of computers is accelerating in our everyday lives, knowledge of their best utilization is of great importance. The individual who does not have a grasp of both the potential and limitations of these devices can be severely handicapped. Regardless of one's role in our society, a minimum knowledge of computers and their capabilities is essential.

Computers are being used effectively and are included in future planning in the educational environment. Computer technology plays an important role in the operation of our schools, enabling educators to access information for more efficient decision making. School districts use computer technology to handle business operations, thereby increasing the purchasing power of the education dollar. The educator is accepting the increased reliability of the information obtained, the speed of handling information, and the variety of reports available to help in the decision-making process.

School administrators and teachers are also increasingly recognizing another important role computer technology is playing in today's schools. Computers are making significant contributions in curriculum, through the teaching of electronic data processing and computer science, and in instruction to assist in the teaching-learning process. With the advent of the micro-computer this utilization has increased and is becoming more available to students.

Computer applications in education at all levels have become more evident. It is the purpose of this guide to acquaint the reader with the many uses of computers in education.

This publication is a second edition produced by the Association for Educational Data Systems (AEDS). The first edition was published in 1971. Many advances have been made, and much growth and utilization have occurred. These developments are included in order to give the reader a state-of-the-art presentation of educational computing. The book is intended to help the reader become familiar with the nature of computers and what they can and cannot do.

Section 2

HISTORICAL PERSPECTIVE

The history and evolution of computer technology represent examples of not only human ingenuity and inventiveness in a single area, but also the abilities of people to traverse the boundaries between many fields. Progress in computer technology is representative of progress in electronics, communications, control systems, psychology, pedagogy, mathematics, engineering, and many other areas.

There are a number of sources from which one may derive a point of origin for computing. The devices of early civilizations which were important in counting and record keeping could be viewed as early computers. Several inventions by Pascal, Leibnitz, Von Muller, and others provided an important foundation for calculating machines.

Automatic computing began in 1812 with Charles P. Babbage, an English mathematician who wanted a machine that could execute complex calculations without any human intervention. One of Babbage's better-known contributions was the Difference Engine, a large adding machine designed to calculate mathematical tables. Because of the enormity of the device, it was never completed in its entirety as Babbage conceived it. Despite these obstacles, Babbage continued his work and in 1833 conceived the Analytical Engine. This machine would be able to add, subtract, multiply, and divide, and store its intermediate results in a memory. Although it was not fully completed, it was to be the first general purpose digital computer.

Another significant milestone was the invention by Herman Hollerith of the system of punched cards. Although a similar device had been developed earlier by Joseph Marie Jacquard of France, Hollerith's application of punched cards to speed the handling of data in the 1890 United States census resulted in a major event in the history of computing. Machines using this system completed the census in one-third the time required to calculate the 1880 census. Hollerith later formed the Tabulating Machine Company in 1896, which was absorbed in 1911 by IBM.

One of the first fully electronic computers was ENIAC (Electronic Numerical Integrator and Calculator) designed by John W. Mauchly and J. Presper Eckert at the University of Pennsylvania in 1945. ENIAC was constructed primarily to produce ballistic weapons tables during World War II but was not completed in time to be utilized in the war effort. The device was massive, requiring over 18,000 vacuum tubes, 1,500 square feet of floor space, 1,500 relays, miles of wire, and weighing more than 30 tons. Having these components operational for the time required to complete a computa-

tion was a feat in itself. Another drawback of ENIAC was the fact that it had to be physically wired to perform a particular task. Reprogramming required changing hundreds of plug and socket connections and considerable time.

A principal figure in the development of computer technology was Dr. J. von Neumann, a mathematician upon whose ideas the concept of the stored program is based. As a result of von Neumann's theories, the EDVAC (Electronic Discrete Variable Automatic Computer) was developed. EDVAC used a stored program which controlled the sequential operations of the computer and paper tape for input. So profound were von Neumann's ideas, he is often considered the father of the stored-program concept. Von Neumann also made numerous other contributions to the field including the development of the MANIAC (Mathematical Analyzer, Numerical Integrator, and Computer) which enabled the United States to produce and test the first hydrogen bomb in 1952.

The first commercially available computer was UNIVAC I (Universal Automatic Computer) built by the Eckert and Mauchly Computer Company. In 1949 the company was purchased by Remington Rand and later became the UNIVAC Division of Sperry Rand. The first UNIVAC computer was used to compile the 1950 U.S. census data. IBM's first commercial computer, an IBM 650, was installed in Boston in 1954.

The computers built between 1951 and about 1960 are typically characterized as *first generation* computers. These computers used vacuum tubes, were large, required considerable power, and needed powerful environmental control devices due to the heat generated by the vacuum tubes. They were expensive, unreliable, and slow by present standards. Programming of these computers was in machine language or by symbolic notation until the late 1950s when FORTRAN (FORMula TRANslation) was introduced. FORTRAN permitted the user to write a program in a mathematical language which was converted to machine language by a compiler. Other first generation computers included the IBM 701, RCA 501, NCR 304, and Burroughs 220.

The development of the transistor in 1947 by Bell Laboratories signaled the advent of many revolutionary events in both the fields of electronics and computing. The arrival of the transistor occurred almost simultaneously with the stored-program digital computer. The synergistic effect of a new component and a new application resulted in an explosive growth of both.

The use of transistors in place of vacuum tubes in computers marked the beginning of *second generation* computers. These computers, built from the late 1950s until 1964, were much smaller than their predecessors, required less power and environmental systems, and possessed increased efficiency, speed, and reliability. Some of the more popular second generation machines were the IBM 1401 business-oriented computer, 1620 scientific-

oriented computer, and 7090-7094; RCA 301 and 601; NCR 315; CDC 3600 and 6600; and Honeywell 300, 400, and 800.

Third generation computers appeared about 1965. These machines were characterized by the use of integrated circuits, increased programming and peripheral sophistication, and overall miniaturization of hardware. Examples of third generation computers include the IBM System/360 and System/3, CDC 6400, DEC PDP-8, and the UNIVAC 1108.

The integrated circuit, which provided an enormous decrease in physical size and an increase in computing power, consisted of thousands of electronic components on a single chip. Progress in lithography has enabled the production of ever faster, cheaper, and lower power-consuming computer elements.

Integrated circuits, silicon technologies, and microprocessors have made possible a vast array of small and relatively inexpensive computers. Minicomputers are available from about \$8,000 and offer users a high level of data processing capability.

As notable as previous advancements in computer technology had been, a significant event occurred in 1975. A small company in New Mexico called MITS offered for sale a computer kit—the Altair 8800 for about \$500. This was a desktop computer which could support high-level programming languages and sufficient memory for important applications. All one needed in addition to the Altair were a terminal and a cassette recorder.

Since the mid-1970s, other small computers have rapidly appeared. Their popularity with consumers spawned a multibillion-dollar industry. Apple Computer, Inc., started in 1975 with a dream and \$2,500, is now a \$600 million company. It is estimated that in 1981 alone, almost 3 million personal computers were sold.

As for the near future, a host of predictions and visions are possible. Some would suggest that our society is near a point in which almost everyone will use computers in their daily lives. The only thing which appears clear at this time is that no one is sure where this technology is going or what its societal impact may be.

Section 3

COMPUTERS IN INSTRUCTION

The emphasis in this chapter is on instructional applications. If used properly, the computer offers the means by which to improve the quality of education. The use of the computer in education for research and administration is ongoing; but it is in the instructional area that its usage has spread and is offering great promise, especially with the advent of the microcomputer. "Instructional computing" has a variety of meanings, but this chapter will deal with the following:

- Computers as an instructional aid
- Computers as a subject of instruction
- Computer-assisted instruction
- Computer-managed instruction
- Retrieval of information for instructional purposes
- Vocational education

This chapter will deal with the computer as it assists the teaching and learning process and will present examples of some of the work being done.

Computer education begins with an appreciation of the immense power and capabilities of the computer, and also an awareness of its limitations and its complete dependence upon human intelligence. As more and more computers are being installed, major countries of the world are becoming dependent on them in many aspects of national life. Whereas the computer was used initially in solving problems of a numerical nature in science and engineering, this usage is now overshadowed by applications in commerce, business, and industry. Computers are information processors. Students must not grow up in ignorance of this new social and industrial revolution. Students may eventually find satisfying careers in developing computers or in working with them in some field of application. Others, less directly involved, will need to be sufficiently well informed to be able to make use of computers whenever appropriate.

Computer Literacy

Although this area is not listed above as one of the uses, it is fast becoming a must for an educated person. It is being considered a basic skill and essential to function properly in our society. The ability to learn how to handle information, solve problems, communicate with people, and help understand the changes that are happening in our society can be aided with the proper use of the computer.

It is important to prepare our students to become "computer literate." There are many definitions of computer literacy, but generally they include the following:

- Removal of fear, anxiety, or intimidation from computer usage.
- Knowledge of what a computer can and cannot do, its capabilities and limitations.
- Recognition that the computer gets instruction from a program written by a person.
- Ability to communicate with a computer.
- Understanding of the variety of ways computers are being used.
- Awareness of the number of opportunities in computer-related occupations.

A variety of approaches are being utilized in introducing computer concepts to students. In 1972, the Conference Board of the Mathematical Sciences Committee on Computer Education recommended the preparation of a junior high school course in computer literacy. In 1978, the National Council of Teachers of Mathematics recognized computer literacy as essential. A position paper stated "... an essential outcome of contemporary education is computer literacy. Every student should have firsthand experience with both the capabilities and limitations of computers through contemporary applications. Although the study of computers is intrinsically valuable, educators should also develop an awareness of computers both in interdisciplinary problem solving and as an instructional aid."

A computer literacy course is now being taught in many school systems to seventh, eighth, and ninth grade students. Various states have incorporated computer courses as part of the ongoing course offerings. Pennsylvania has prepared a three-week computer literacy course. This course was designed with the following factors in mind:

- Teachers of all disciplines need to be computer literate.
- Students of all ability levels deserve the chance/need to become computer literate, not only the gifted or college preparatory students.
- Effective computer literacy instruction requires direct interaction with the computer.

The existing course is an introduction and provides an awareness in the following areas (opportunity to use the computer is available to the student):

- How computers operate
- Applications of computers in various aspects of life
- Implications of computers and computing in our lives
- Rudimentary BASIC programming

The Minnesota Educational Computing Consortium (MECC) with funding from the National Science Foundation has prepared modules for computer literacy. Learning packages, written for students entering junior high school, are available in science, mathematics, and social studies. Each

learning package includes background material, student activities, text materials, visual aids, and instructions for computer-based learning.

Cupertino Union School District in California (K-8) with an average daily attendance of 13,000 pupils has the goal "all students will have an opportunity to become familiar with the operation of a microcomputer. They will become aware of the widespread use of computers in the world, and be aware of the computer's capabilities and limitations." This course is divided into grades K-3, 4-6, and 6-8. In grades K-6, the use of a microcomputer is part of the normal school activities. In grades 7-8, a specific course in Computer Awareness and Introductory Programming also gives students some of the knowledge needed to make wise educational choices in high school and eventually career choices.

A Guide for Computer Literacy in the K-8 curriculum has been produced by Human Resources Organization and Montgomery County Public Schools, Maryland, under the sponsorship of the National Science Foundation. Objectives and activities in each of the subject areas (math, science, social studies, and language arts) are suggested. The curriculum is organized in six strands:

- Using and Developing Procedures
- Using Computer Programs
- Fundamental Concepts about Computers
- Computer Applications
- Impact of Computers in Society
- Writing Computer Programs

Each strand includes a sequence of objectives from grades K-8. The objectives are suggested for introduction at particular grade levels. Students continue to use and build upon these skills in later grades.

It seems appropriate that students begin a broad-based program of understanding and appreciation of the capabilities of the computer early in their school life. This exposure need not be specific in terms of developing expertise in programming; instead, it should be geared to provide a general foundation for subsequent education in more specialized aspects of computer work for those pupils wishing to pursue this area, or a broad-based introduction for those who will not take further specialized courses in programming.

Computers as an Instructional Aid

The computer has an important application in the classroom in the teaching of algorithmic analysis, the step-by-step procedure necessary to solve a problem. The need for the clear definition of a problem for solution using the computer makes mathematics and science a dynamic and individual experience for the student. It eliminates the tedious calculations that may be required to open new areas of investigation.

The computer is a boon to both the deductive and inductive learning pro-

cess. In mathematics classes the applications and uses of the computer are many. Complex calculations are carried out, and results displayed almost instantaneously. After the computer program is developed and usable, both the teacher and students can concentrate on the mathematical structure and the physical significance of the results obtained. From the utilization of problem analysis and exploration, the student develops a feeling for what is likely to happen and for the intrinsic mathematical and physical properties of the system represented by the problem. Students then participate directly in the investigation of the mathematics concepts and can learn by inference.

The National Council of Teachers of Mathematics in 1980 issued recommendations regarding the teaching of problem solving. It is stated that the curriculum be reorganized around problem solving strategies and processes. This concept need not be confined to any one discipline. The student has used computers as an aid to problem solving over a period of years in a wide variety of disciplines that call for learners to state their own problem, test hypotheses, propose and then evaluate solutions. It may also involve the student in writing a computer program that will solve a problem. An algorithm is the expression of an idea or problem in the form of a prescribed set of instructions. An individual who is able to write an algorithm for computer solution has a new intellectual tool valuable in most subject matter areas now being taught.

Computers and their languages give students new approaches to thinking and new ways of dealing with information and knowledge. They also bring a concreteness to otherwise vague or abstract ideas. Through graphic display and control of physical objects the computer creates dynamic reactive situations for students to explore.

An approach, developed by the Artificial Intelligence Laboratory of the Massachusetts Institute of Technology, is to create an environment in which the student must "teach" the computer what to do and how to do it. LOGO, a computer language, creates a computer-based environment in which mathematics and other areas of "formal" learning can occur in a natural manner. It puts the student in control of the computer and provides a discovery method in the solution of problems. Students decide what to do and then carry it out. It allows a student to determine the level of challenge he or she wants to explore in the areas of problem solving and communication skills. Learning is to occur naturally as the student works through the skills that are necessary to accomplish a task. This discovery method of learning is to encourage the student to gain control over the learning process. "Turtle Geometry" introduces fundamental concepts, as well as developing geometrical ideas, by having children tell an "electronic turtle" how to draw pictures on a video screen. Thus, even very young children, through a link with concrete experiments, can learn how to think through a problem. Research in this area is still ongoing, but beginning results look promising.

Computer as a Subject of Instruction

Thirty years ago, computer science as a discipline did not exist. Separate courses were offered in some large universities, but primarily to graduate students. Once the number of computers started to grow, the need for computer science grew rapidly. It soon became apparent that computers were useful and essential in many areas. The use of the term "information science" emerged to indicate that the computer is an information-processing machine. Many colleges and universities now use the words "Computer and Information Science" to denote the department that conducts courses and research in the computer field. Computer science and programming courses are being given at the secondary school level. These courses are generally of a survey nature providing the student with a broad overview of computer science and ability to program in a variety of languages. Computer science can be defined as "the science of representing and processing information with the logical engines called computers." The pure computer scientist is concerned with the hardware, system software, and with the theoretical aspects of computers. The applied computer scientist is more concerned with the applications and the problems of efficiently getting information in and out of the computer. As computers are becoming more and more an integral part of our environment, schools and colleges are building the knowledge of computers and their applications into curricula and courses at all levels.

Programs at the bachelor's level have increased and are growing. At the master's level, courses are obviously more advanced and concentrated than at the bachelor's level. Existing programs at the doctoral level are quite varied and are often dependent upon the interests and capabilities of the faculty. The objectives of these programs are to produce students who are capable of conducting research, of teaching computer science, and of making original contributions in the field of computer science.

The development of computers and information science education was assisted by the formation of professional societies whose members worked in the area. The Association for Computing Machinery (ACM), the Data Processing Management Association (DPMA), the Institute for Electrical and Electronic Engineering (IEEE) Computer Society, and the Association for Educational Data Systems (AEDS) contributed in this area. For example, ACM published detailed recommendations for an undergraduate computer science curricula in 1968, and then updated it in 1978. Both DPMA and IEEE have published curriculum recommendations. AEDS, through its workshops, conferences, and publications, has helped to provide guidelines to schools, colleges, and universities.

Computer science is more than computer programming, though computer programming has been shown to be of interest to many students. For the slow student, it offers a new topic free of the many frustrations and hostilities associated with topics which depend on concepts which have not

been mastered. For the gifted, it provides a tool for probing challenging problems.

Computer science courses are given at the high school level. ACM has developed a year-long computer science course for high school students which includes topics such as artificial intelligence, information retrieval, and modeling. It also covers the design, representation, testing, and debugging of procedures to solve problems.

The course "An Introduction to Computers and Computing: A High School Course Outline" is intended to be a general education course to be studied by every student, not restricted to students who are math and science-oriented. Students learn concepts essential to living in our modern, computerized society, and gain a base of essential knowledge from which they can move to more specialized courses. There are four strands woven together to form the course. Each strand has its own content, but each is closely related to all the others. The four strands are:

- Applications—how computers are used as tools in many different kinds of tasks.
- Programming—how people give direction to computers so that the computers will perform the desired tasks.
- Computer Environment—how the physical and organizational parts of computer systems work.
- Social Impact—how computers and information processing create change in our society.

Word Processing

The ability to manipulate information is now available with an ease that was unthinkable a few years ago. With a text editing system only the errors and revisions need to be changed. Most of the document can remain untouched. Blocks of text can be stored separately and combined in any order. Multiple copies of a letter can be personalized for several recipients by simply changing the heading. Blocks of text throughout a document can be changed with a single command.

The capability allows students to compose on the computer's keyboard, save their work so that it may be recalled at a future time, edit any aspect of what has been written, shift sentences and paragraphs, and print out a finished product without having to be concerned about spacing, pagination, heading, or margin. Using a word processor for editing eliminates the mechanical aspects of erasing, cutting, and pasting, and allows the writer to focus on content and style. With an automated dictionary capability, students can quickly learn the meaning and correct use of words.

Word processing software is available for most widely sold general purpose microcomputer systems, but if one wants "letter quality" printing, the printer may cost more than the rest of the microcomputer system.

Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) can be considered as a system in which a student interacts with a computer. The computer is used to provide instruction in the form of drill and practice, tutorial, games, and simulations.

As early as 1960, educators began to look to the computer as an aid in overcoming the inherent shortcomings of the simple teaching machine or the programmed textbooks. CAI is based upon some of the same theoretical foundations as programmed instruction. In its early stages of development, programmed instruction included the following essential characteristics:

- Precise statements of instructional objectives in behavioral terms.
- Material presented in a carefully and logically sequenced order leading to criterion performance.
- Provision for continuous and active student involvement.
- Provision for continuous feedback on student performance.
- Provision for continuous reinforcement—usually in the form of success.
- Means by which the student is able to proceed at his/her chosen rate of speed.

Computer-assisted instruction added these capabilities:

- Sequencing of information presented as a function of student performance. For example, on the basis of his response on a specific criterion frame and/or history of performance on related criterion frames, a student can be (a) given additional remedial or practice material¹, (b) continued in the linear sequence, (c) branched ahead to more challenging material.
- The student is given truly "immediate" response confirmation or correction.
- A wide variety of presentation modes, such as graphics, audio, motion pictures, etc., can be used. Voice recognition techniques which enable the computer to respond to spoken commands are now being explored.

Much of the CAI development that was initiated in the United States in the late fifties and early sixties was done at Florida State University, Stanford, the University of Illinois, and Dartmouth. CAI research and development continues today at many colleges and universities.

The Plato system, developed and still operational at the University of Illinois, is probably the most well-known CAI project in the world. Plato-based CAI research and development are found today in many business, industry, and military applications as well as traditional educational settings.

Drill and Practice

The first application of instructional computing was in mathematics to provide drill and practice. This is the simplest instructional system. Instruction provided by this approach is usually supplementary to the traditional instruction provided by the classroom teacher.

The drill and practice material that is available usually has the following characteristics:

- Diagnostic—a pretest shows whether or not the student needs help. If the student scores a certain percentage or higher (can be set by the teacher), the next pretest is given.
- Levels of difficulty—student is assigned to remedial instruction at the level needed.
- Assessive—a posttest allows the instructor to assess mastery.
- Individualized—each student is working at a separate lesson and at a different rate.

Some drill and practice computer programs give students the options of (a) deciding how they want to progress through a sequence given their present level of ability, (b) determining the number of problems they wish to do, and (c) determining the level of difficulty of these problems.

Since the "early days" of instructional computing the following improvements have been made:

- Programs can be presented in an animated gamelike format.
- Features like immediate feedback, instructional frames, variety of praise and critical remarks, and management of students' records are included.
- Programs can be developed without knowledge of computer programming using authoring languages.
- Programs are available in many areas, including vocabulary, mythology, driver education, geography, chemistry, and physics.

Tutorial

The tutorial system is intended to provide as much of the actual instruction as possible. The tutorial assumes the major burden of instruction rather than a supplementary role, like the drill and practice system.

A student is led through the material in an orderly way as a teacher would do, the computer system dispensing information, asking questions, explaining, and repeating, depending on the student's answers to questions about the lesson being given. While on-line, the student terminal is directly connected to the computer so that the interaction is conversational. It appears to the student that he has the full attention of the computer teacher.

In tutorial instruction, new material is presented directly from the computer. The computer is used to monitor the student's activities, which include asking questions, and dependent on the student's response, branch within the program.

Computers are programmed to diagnose the student's ability at the outset and then put the student at the appropriate place in the sequence. Computers move the learner to the next level of difficulty as soon as a predetermined number of questions have been answered correctly. Tutorial programs need to anticipate a multitude of student responses and must include appropriate branches depending on responses.

The School District of Philadelphia uses tutorial instruction to help meet the needs of inner-city youth. The major thrust is to help students improve their basic skills through programs that enable each student to work at his or her own rate, providing self-direction for learning, fostering the development of thought processes, and encouraging motivation for learning. Through the use of individualized tutorial computer lessons, students begin at their level of understanding. Material that is not mastered is presented again in a different manner as often or with as much variation as needed to produce sufficient comprehension. A reading program helps the teacher develop and monitor an individualized course of study, building as much on the child's competencies as on defects. Because the student is continuously and actively involved, receiving immediate feedback on responses, he/she becomes an active partner in the learning process and is aware of progress as it occurs. A mathematics tutorial program presents students with highly individualized exercises that reinforce and review material, enabling them to proceed at their own rate.

Simulation

An important contribution of computers to education lies in the broad area of simulation. One area of simulation builds or examines a mathematical model of a system. The modeling notion of simulation allows one to identify and explore the influence of the various parameters of a system. A model, as it is used in systems analysis, is a symbolic representation of a real life system. A model is usually expressed in the form of mathematical equations or expressions and does not resemble the real system in a physical sense. A flowchart, for example, is a model of a computer program—a graphic analog.

One might build models for the instructional aspects of education and manipulate some of the variables that affect learning. Frequency of review, rate of presentation of new material, various reward schedules, and so on, can be varied in order to study their relative importance in the overall learning outcome. At many business schools, computers are being used to provide interactive models through which teams of students learn management techniques. Resources of a manufacturing operation such as capital, raw materials, people, production schedule, etc., are used as variables. The overall objective is to maximize profits by making decisions on how to develop these resources. Weeks of time are compressed by the computer, so that results of decisions are immediately available throughout the learn-

ing session. Elementary school students are being taught basic economics by being allowed to run the economy of an ancient land. The child plays the role of king and has control over economic factors of a country. The computer, in dialogue with the child, demonstrates the effects of a decision. Thus, simulation can provide learning experiences that might otherwise not be available, for reasons of safety, equipment cost, prohibitive setup time, or other factors of cost or convenience.

One of the main values of computers, used in the simulation of environments, resides in their power to control models. This permits the artificially created situations to conform as closely as possible with reality in the following manner:

1. Accurate calculations may be quickly made from simple or complex formulas.
2. "Random" numbers or numbers based on actual probabilities may be generated and used to modify the calculation of the outcome of a particular decision.
3. Complicating circumstances may be methodically introduced in a logically consistent manner not foreign to the way in which this would happen in the real environment.
4. Situations or elements may be introduced on a random or probabilistic basis.

Simulation represents the key aspects of an environment which the student can affect by making decisions to change specific parts. It offers an exciting means of approximating or testing cause and effect. The user becomes actively involved, making choices and decisions that affect the eventual outcome.

While a variety of simulations are available, these reviewed below should provide the reader with some insights regarding their nature and functions.

Lemonade Stand. Lemonade is a simulation which involves economics, mathematics, and problem solving and is of interest to students at many levels, from elementary through high school. Individual students, or teams of students, have the responsibility for running a lemonade stand. As a result of a weather report, the students must decide how many glasses of lemonade to make, how many advertising signs they'll need, and what price to charge for their lemonade. A daily financial report is provided for each stand. Weather and other conditions change randomly from day to day. This simulation helps children learn to understand and use terms like "assets" and "net profits," learn more problem solving skills, and work together with other children.

Oregon Trail. Another simulation which is popular in the middle grades is Oregon Trail. The program begins with a family's preparation for a journey to Oregon. The instructions include a statement of the supplies that will be needed, their cost, and their importance. The decision as to how

to spend the family's savings is left to the student. The computer provides the unexpected happenings—hostile riders, friendly Indians, lost children, etc. The journey proceeds in two-week increments with choices as to the need to hunt. At the end of each interval, the travelers are given an accounting of their supplies and an indication of their progress along the trail.

Consumer Game. The purpose of the Consumer game is to teach adolescents about the problems and economics of installment buying. This is accomplished by placing students in an artificial or simulated environment which presents a number of situations requiring many of the same decisions players will eventually make in real life. Players learn:

1. To compare the interest rates charged by different finance institutions;
2. That their credit rating (outstanding loan commitments) can affect their ability to borrow;
3. To understand fully the implications of contracts before signing, and;
4. To appreciate the mechanics of that sector of the economic system concerned with the consumer credit.

In another facet of simulation, students can develop their own models as a development of their proficiency in programming. These student-developed dynamic models can be either simple or complex depending on the grade level and ability of the students. A simple mathematical model might be an equation indicating the volume of a rectangular solid to which the student can assign different values to the variables in order to investigate the changing volume as the dimensions change.

Using simulation, students can develop intuitive comprehension of the phenomena they are studying; they can explore interrelationships between variables which define the phenomena; they can detail the relative importance of parameters and the sensitivity of the simulated system to changes in these parameters; they can test hypotheses concerning the phenomena; and they can establish values of the parameters of the system.

Scatter. Laboratory experiments may involve considerable expense, time, and equipment—resources which schools may not have available. It is possible to simulate a laboratory experiment on a computer. Scatter is one of many simulations that were developed at Chelsea College, Great Britain. The student uses the computer to conduct a series of experiments on the scattering of particles. This simulation experiment is divided into three separate parts. The first of these is easily understood by all students and deals with picturing concrete objects from simple collision data. The second is more complex, requiring the student to use mathematical models of physical objects. The final section involves a major investment of time and effort on behalf of the student as well as the teacher.

Summary

The inherent limitations in classroom teaching which patterns instruction to some hypothetical average student rather than to needs of individual students have been recognized for years. Conventional classroom methods critically limit or make nearly impossible efforts to individualize instruction. A high turnover rate among teachers aggravates the problem.

Although teachers have been trying for many years to individualize work for each child in the classroom, even the most successful teachers could not approach what the computer is able to do. The student can receive an individualized lesson and can actively engage in the learning process. Once the learner's needs have been determined, the computer channels the appropriate instructional levels of materials to the student based on the learner's rate and learning style.

A classroom teacher cannot humanly do in one day all that the computer does in the way of diagnosis, drill, and grading of each child on a daily, individual basis.

Therefore, some of the advantages of CAI can be stated as follows:

1. The machine never gets tired.
2. The instruction is private, with the individual proceeding at his/her own rate. The slow student is not embarrassed or pushed ahead without comprehending what's going on. The accelerated and advanced student does not get bored by a pace directed to the "average" student.
3. The student is given an opportunity to advance to new work or repeat material aided by a training system which monitors his/her performance.
4. Curriculum is developed and tested.
5. A complete, instantly available record is provided on each student's achievement.

The use of the computer in instruction does influence and change the role of the teacher. The teacher, relieved by the computer of chores that a machine can do better, is freed for those responsibilities which only human beings can do.

Computer-Managed Instruction

Computers are used to support teachers by relieving them of many management functions. A computer-managed instruction (CMI) program can have the following characteristics:

- Generate or give diagnostic tests, or both
- Score tests and print out profiles of individual or class performance
- Collect and maintain a record of the number of questions answered correctly and incorrectly
- Provide learning prescriptions to a student based on performance
- Generate problem sets and examinations

- Generate lists of materials that address a particular content area, need, or interest
- Create lists of students with similar needs, problems, or interests
- Direct students to alternative learning resources

The Cincinnati Information Management System (CIMS) and the Michigan Teacher Support Systems are two examples of management systems.

Computers can be used to determine courses of study for college students. For example, students at the mathematics learning center of Miami-Dade Community College are assigned to one of four modes of instruction for an appropriate mathematics course on the basis of test results.

A computer program that tests the achievement of high school students is being used in a Minnesota public school system. The program helps students and parents monitor student academic progress, pinpoint stronger skills, and identify areas that need additional study. A variety of reports are available that facilitate instructional decision making. One is a progress card for students which gives a cumulative summary of previous tests in that subject. The teacher receives a report for each test showing areas of strength and weakness and a summary report showing progress to date. Originally written to run on a large system, it has been converted to run on a microcomputer.

In computer-managed instruction, the primary function of the computer is to assist the teacher and student in planning instructional sequences, either on the computer itself, or the actual instruction may be a self-instructional package (programmed instruction), or other media. The computer offers a "prescription" to the student. The student does not constantly come in contact directly with the computer. A CMI system does not teach the student, but functions as an information system which records the student's responses and monitors his/her progress. The role of the computer is that of monitoring and operating an information system which is used to supplement traditional instruction.

The computer may introduce the student to a concept or other item of information and then test him on it. If the student has understood the material, he may be told to study more difficult concepts. If the lesson gives him difficulty, he may be assigned material designed to give him clarification and individual tutoring in the particular problem area.

A student enrolled in a computer-managed instruction system may be administered diagnostic tests to determine overall achievement status and particular learning characteristics. Information resulting from the prescribed tests will be stored in the student data file. These records might include information about a student's intellectual interests, background, task performance, goals, meaningful experiences, failures, and personality conflicts. These records would be used by a CMI system to make the teaching decisions concerning each individual student.

Computer-managed instruction relies upon a variety of multimedia ma-

terials. CMI as a system of instruction offers an individualized, multimedia approach to instruction. The student is directed by the computer to a variety of media which best suit his or her optimum learning characteristics. It uses the capability of a computer to manage the progress of a student through a sequence of instruction, testing that progress at many points. Students benefit from the immediate feedback capabilities of the computer even though there may be no direct instruction via the computer. The system can be assumed to involve testing, diagnosis, remediation, and recording of information under the direction of a teacher. The remediation can be in the form of media and texts available to the student for individualized study. (See Figure 1.)

There is a close relationship between CAI and CMI: both can use the computer to assist the learner. CAI uses the computer to present instruction via a terminal, while CMI may use a terminal to "manage" the instruction.

The CMI projects are based on specifying clearly "behavioral objectives" (what we want the student to accomplish), using the computer to measure a student's individual performance based on these objectives, and then prescribing from an inventory of instructional resources material related to the objectives and to the student's needs.

The procedure could be as follows:

1. Identify the subject to be taught.
2. Give the student a test on the instruction.
3. Diagnose errors based on the test results.
4. Provide the student with reference material based on the errors made.
5. Have the student move on to the next unit when he reaches an established criterion.

Information Storage and Retrieval

The need to access and use data bases is becoming increasingly important. Information can be stored in a computer and accessed when needed. Many retrieval systems are in operation including airplane and motel reservation systems, tax systems, medical files, census data, library systems, and financial data.

Commercial information networks such as The Source, Dow Jones, CompuServe, and MicroNet are serving large numbers of users. The available data bases are providing masses of information for teachers and students.

Guidance and Counseling

Another application of the computer in education is in the area of counseling. The counselor of today is often caught in a paradoxical situation. He/she spends ever more time collecting, recording, and evaluating data about students, and ever less time relating to those students as human beings. Yet, today's advanced information processing technology should enable

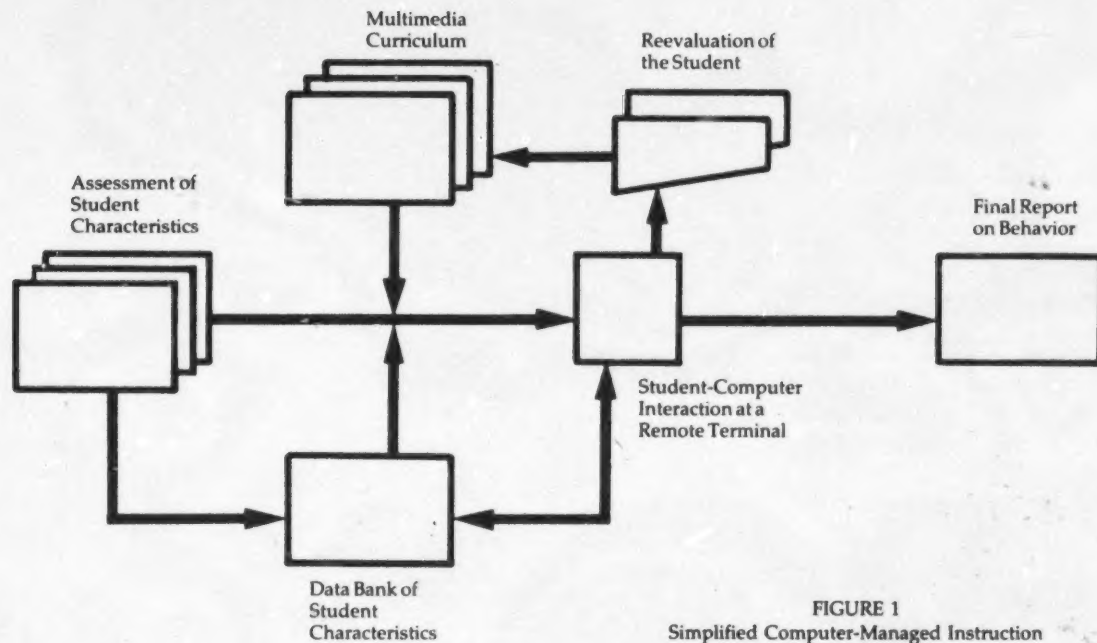


FIGURE 1
Simplified Computer-Managed Instruction
(CMI) System

the counselor to shift to the computer the burden of data handling, allowing time to fulfill the unique functions of the role.

The student guidance counseling system in high schools, colleges, and universities provides individualized aid to each student to help reduce the uncertainty of educational-vocational plans. The computer's ability to accept, store, analyze, and display information rapidly aids the counselor and the student. With its capacities for rapid and accurate computations, its infallible memory, its speedy retrieval and effective display, its freedom from human scruples of bias and mood and its complete objectivity, the computer can change the organization and functioning of counseling services.

Some examples of programs and data bases currently available to educators are Computerized Vocational Information Systems (CVIS), Guidance Information System (GIS), and the Michigan Occupational Information System (MOIS).

Career information, knowledge of occupational opportunities, and educational and financial information are offered to students in the Philadelphia area through the use of a computer-assisted program known as Vocational Information through Computer Systems (VICS). The career information program offers local up-to-date data on 467 occupations and an opportunity to ask many questions about each occupation. Information is given to students about employers in the area who hire students for entry level positions. In addition, the special requirements for a job opening are listed. A college search program provides facts on approximately 600 post-high school educational institutions in Pennsylvania, New Jersey, and Delaware, as well as popular colleges throughout the United States. A financial aid scholarship search program provides more than 780 sources of aid for post-high school training. With this information, students are able to make better decisions concerning their career or educational plans. In the past, teachers and counselors found it difficult to supply this information, due to the large number of students to be served and the immense quantity of time and resources required by each counselor in order to help students effectively prepare for their future.

In Discover, the user makes tentative vocational choices based on self-information. The system provides the student with possible roads of training to occupations selected and provides search strategies. In CVIS, students choose one to six levels of education and one of eight areas of interest. Based on this choice, the computer displays occupational titles which the student may explore. Students then move to scripts on four-year colleges, technical schools, apprenticeships, and/or the military to find programs which provide training for occupations.

The Genesee Intermediate School District in Flint, Michigan, has an Educational and Career Exploration System (ECES). It utilizes computer technology, color filmstrips, microfiche presentations in exploring occupations and education options, learning career decision making and employ-

ability skills, and in establishing their career plans.

A number of sophisticated guidance and information systems are available that have demonstrated their utility in helping people in the career decision-making process and in improving access to career information.

Vocational Education

The demand for trained personnel is substantial. There is a need for people in the fields of computer operations, programming, systems analysis, and as technical representatives. Recent requirements of industry and science have created a tremendous demand for people skilled in the technical field of data processing and information science. Industries in engineering, electronics, missiles, and manufacturing need data processing technicians who can work side by side with the engineer or scientist to help analyze the specific problem at hand and devise a way to instruct the computer to achieve the desired results.

Interest in business data processing has grown. A computer professional in business finds it essential to understand how a business functions. Courses in accounting, marketing, finance, management, economics, etc., are valuable for students entering the profession. The computer science departments are usually oriented toward computer engineering and computer science. The computer engineering graduate is concerned with design of computer hardware and maintenance. This program is designed primarily to prepare graduates for employment in positions directly related to the hardware of computer systems. The computer science graduates are primarily involved with the design of software, operating systems, utility programs, etc.

The community colleges and vocational technical schools and institutes train the computer operator, coder, and beginning programmer. Two-year, post-high school institutions also offer courses in this area. Graduates are able to, for example:

- Analyze problems in conjunction with a systems analyst.
- Plan detailed logic, using a program logic plan or schemata such as flowcharts, decision tables, or structured programming charts.
- Use a problem-oriented language to convert the plan into the application.
- Communicate computer technology effectively with other programmers, and with clerical personnel, analysts, management, and users.

A four-year degree is usually required for the professional programmer, programmer analyst, and systems analyst. A master's degree is traditionally required for someone working at the level of systems analyst.

Good careers also are available to those who know how to program, operate, and control data processing equipment. There is need for people trained in science and familiar with the basic concepts of systems and the stored programming concepts of electronic computers. Young men and

women who wish to prepare for technical careers in this area are looking to vocational education for their educational opportunities. The vocational education field, within its present framework, can administer the type of program that can help fill the demand for trained personnel on the technician level. There are many existing curricula on a post-high school level and in junior colleges that have helped individuals acquire a marketable skill.

Word processor operators are also in demand. Objectives of a word processing curriculum are to familiarize the student with the word processing machinery, learning the fundamentals of operation so that they qualify for a position in business or industry.

Other Projects

In this guide, several school programs have been referenced which describe the role of the computer in education. Naturally, we cannot begin to cover all of the computer projects currently operating throughout the United States. The following are, therefore, some brief descriptions of a few projects selected as a representative sample.

An Educational Technology Center has been formed at the University of California, Irvine. The primary focus of the center is the use of the computer as a learning aid. The center continues the activities in computer-based learning conducted during the last eleven years. The center works on a wide range of research and development activities leading to more effective use of the computer and associated technologies in learning environments. Development of software is continuing which follows a process including:

- Instructional (pedagogical) design of material.
- Visual design of the material as it appears on a computer display.
- Programming details beyond the visual design.
- Formative evaluation, early use, and gathering data.
- Improvement is based on the formative evaluation.
- Final summative evaluation study.

Writing teams are composed of faculty members with the support of graduate and undergraduate students.

A vocational program is being offered at Portland Community College entitled "Computer Software Technician." The curriculum was developed jointly by Portland Community College and an advisory board comprised of representatives from local electronics manufacturing companies. The goal of the Computer Software Technician Program is to train a technician who has the skills to write and develop microcomputer applications software under the guidance of a software engineer.

A computer-augmented video education project is in operation at the United States Naval Academy. The project is designed to produce a series of modules involving computer graphics display and integrated computer-controlled television to help students learn the essentials of electrical engineering. Each module contains a review of the theory and basic sample

problems followed by an exercise to test students' proficiency.

Computer-based instruction in the Montgomery County Public Schools, a large public school system in Maryland, includes computer-assisted and computer-managed instruction, computer literacy, computer mathematics, and problem solving. The interactive use of computers for children begins as early as third grade while the management system in mathematics monitors individual student progress from kindergarten.

Wayne County Intermediate School District is an educational resource center serving the third largest county in the United States, the Detroit metropolitan area. It supports the acquisition and utilization of hardware throughout the 36 local school districts. The creation of a demonstration center enables them to serve educators in the following ways:

- Compare and evaluate hardware and software
- Attend training programs
- Provide an information center for literature.

Dartmouth University serves as one of the prime sources of the use of computers in education. During the early seventies, Dartmouth, in conjunction with the Universities of Oregon, North Carolina, Iowa, and Texas formed a consortium (Conduit) to evaluate and distribute instructional computing materials. Conduit is located on The University of Iowa campus.

The School District of Philadelphia uses the computer to aid in the solution of many educational problems. It has sought to serve the following objectives:

- To use computers to facilitate and individualize instructional processes
- To develop and implement courses related to computers so that students can use these as tools, be aware of the effects they will have on their lives, and recognize their impact on society
- To develop curricula designed to acquaint students with career opportunities in data processing and to help them develop the skills necessary to enter this vocational field
- To develop, implement, and evaluate new and promising techniques of teaching such as those involved in gaming and simulation
- To train teachers and other staff members of the school district in the use of computers so that they may apply them to the improvement of instruction in the school district.

Rosemont, Minnesota, uses computers throughout its school system. They maintain an extensive program based on microcomputer technology in the classroom. In addition to assisting teachers in the instructional process, the computers are also used as a manager of instruction. Their applications range from grade recording, test scoring, and attendance reporting in classrooms to inventory systems for textbooks and library books to substitute teacher files, word processing, and planning for the administrator.

Houston's Region IV Education Service Center coordinates instructional

computing services for 101 school districts in Texas. The center serves a variety of functions from providing equipment to conducting workshops and offering consultations.

In the San Diego County School District, California, the use of microcomputers is extensive in the elementary schools. In the elementary district, the usage is primarily for instructional games and drill and practice. The high schools use the computers for drill and practice, direct instruction, teaching programming, and simulations.

A New York City project is aimed to "make intensive exposure to computers available to children at an early age." Computers will be used in all subjects, from mathematics to writing. In addition, there will be "children's engineering" for girls as well as boys to develop an understanding of everyday technology, such as home appliances, radio, television, and computers. Each child will have constant access to the computer. It will use LOGO as the computer language.

Chicago city schools have used computers in instruction since 1971. Lessons in mathematics and reading, for example, are used with fourth through eighth grade children in the inner-city schools. Simulations, tutorials, and problem-solving material in many areas are also being utilized.

Future

A basic trend in education has been evidenced over the past 20 years and can be described as a trend toward complexity. Alternatives to the "lock-step" of grades are used within many administrative systems, and non-graded, continuous progress is becoming increasingly popular. Along with the idea of continuous progress comes two not-so-new approaches. These are individualization in instruction and flexible curriculum scheduling. The student may no longer be required to be confined to one, two, or three tracks in a curriculum. The course offerings are increasing at a fantastic rate. All of this means increased complexity in administering education to students. The consequence of this complexity is the necessity of establishing new methods of instruction scheduling, reporting, and grading, to say nothing of budgeting, planning, and building of facilities and other aspects of educational administration.

A solution to some of the administrative and instructional aspects of education lies in the increased use of computers. Computers have the capability for planning and administering programs of study. Computers also have the capability of scheduling, rostering, reporting, and grading students as well as the capacity to retain in data bases information for reporting, planning, scheduling, and research.

With regard to the instructional subsystem of education, individualization is an educational approach. Although a tutorial (individualized) approach has been considered an ideal educational method, the resources for large-scale individualized instruction have never been available. The re-

sources, in the form of microcomputers, will become increasingly available in the future. Indeed their availability may well be a requirement for adequate functioning of the educational system. Without an automated approach to education, individual teachers will not be able to monitor the educational progress made by the students.

The enthusiasm for computers is almost everywhere. The computer capabilities that were once restricted to a fortunate few—color, high resolution graphics, and sound—will soon be available as standard in relatively inexpensive systems.

Combination of computers with videodisk technology has promising and technologic applications for education by combining the power and logic of the computer with the visual-audio feature of television.

The merging of communications and computers is causing the growth of an information-based economy—the transition from an industrial to an information society.

Electronic mail enables teacher, student, or administrator to communicate with each other through computer terminals. Teachers could leave messages for students about their assignment progress, or attendance, and students could work together on joint projects.

Dynabook personal computer concept was introduced by the Xerox Learning Research Group in the early 1970s. It is envisioned to be a small and portable device, the size of a notebook, which can both take in and give out information in quantities approaching that of human sensory systems.

It is difficult to predict more than six months ahead as hardware and software advances continue to accelerate. The production of education software is increasing and its distribution more assured with the formation of regional information centers linked together to a national network. Schools that have more than one machine will continue to be linked together to share expensive peripherals like disk drives and a printer. Access to national networks will provide more resource sharing. The mass production of home computers will provide each student with an inexpensive computer/terminal by the end of the decade.

Half of the jobs in the American economy are information-handling jobs and most of these have become computerized or electronic. Jobs done by humans will be taken over by robots. The auto industry is a prime example both in the United States and in Japan. For example, computers are programmed to screw light bulbs into panels, spray paint, weld, load and unload parts, and respond to simple verbal directions. Out-of-school learning environment will spread so that schools as we know them today may have no place in the future.

The future of technology in the educational systems lies not so much in the replacement of manual processes, but in their use in new processes. Instantly available prescriptions for education and guidance are only one way of using the capabilities of the computer. The modeling (simulation) of the

environment is another use that can be made with the computer. The potential is enormous, but requires the educators to "rethink" the role of the computer in terms of the characteristics of the learner and the capabilities of the computer. The role should not be to automate but to be an integral, dynamic part of the whole education system.

The use of technology in education and particularly that of the computer will continue to expand. It is hoped that this booklet, in addition to describing some of the uses of the computer in instruction presently in existence, will motivate the reader to begin thinking of the vast possibilities of the applications of the computer in this important area.

Section 4

MAIN COMPONENTS OF A COMPUTER SYSTEM

We are now ready to define a computer as a device capable of accepting information, applying prescribed processes to the information, and supplying the results of these processes. It usually consists of input and output devices, storage, arithmetic and logical units, and a control unit.

In any computer, data are entered, processed, or operated upon by some method and then reproduced as new data (see Figure 2).

Information Flow in a Computer System

Data can be thought of as information to be processed by a computer organized for a specific purpose. For example, class, grades, and attendance information are data processed by a computer to make up report cards. The information is processed mathematically and logically. Comparing, sorting, and rearranging of information are the kinds of logical operations performed by the computer. The word "processing" refers to the operations performed using the information that is fed into the computer (input).

As Figure 2 illustrates in a simplified form, several items (A, B, and C) of data are entered or "input" into the computer. Some predetermined sequence of operations is performed on the data, and the result is new data (D, E, and F). Each of the three blocks in Figure 2 can be considered steps in a linear sequence of operations. The steps are time-distributed which

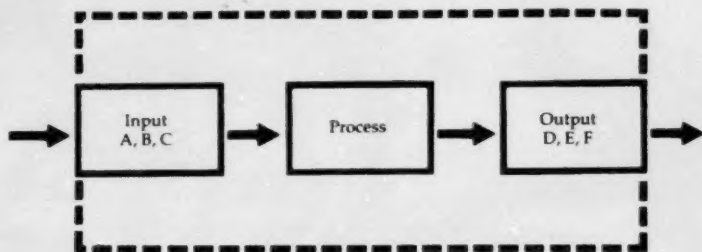


FIGURE 2
Simplified Computer System

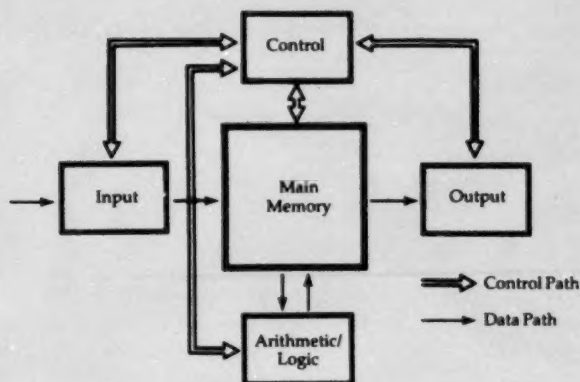


FIGURE 3
Generalized Digital Computer

means that one step must be completed (or at least begun) before the next step is begun.

The computer is made up of many basic circuits put together like building blocks, each containing electronic components such as transistors, integrated circuits, diodes, etc. This equipment is frequently called "hardware" and may be considered to consist of five sections, each having a distinct function. However, the operation of each unit is dependent upon the other. In Figure 3, the arrows indicate the flow of operations.

Figure 3 depicts an expanded and more generalized schematic representation of an electronic computer. The central processing unit (CPU) has been separated into three units—the control unit, the main storage (memory) unit, and the arithmetic/logic unit. In some configurations, the CPU contains the control unit and arithmetic/logic unit with main memory as a separate component. Two sets of arrows are included in the diagram; one depicting the path through which data flows; the other specifying the control path.

The arithmetic/logic unit, control unit, and storage or memory unit are all contained in one cabinet (see Figure 4).

The console unit added to the CPU portion of the earlier figure provides a means of directly controlling the internal operation of the computer. The console may include a television-type display (CRT) with a typewriter-type keyboard attached to it. The cathode-ray tube (CRT) can display information stored in memory. Also, the operations that are about to be performed can also be specified and displayed on the CRT. The computer operator can use the typewriter to type messages, to stop, start, and otherwise assume control from the CPU.

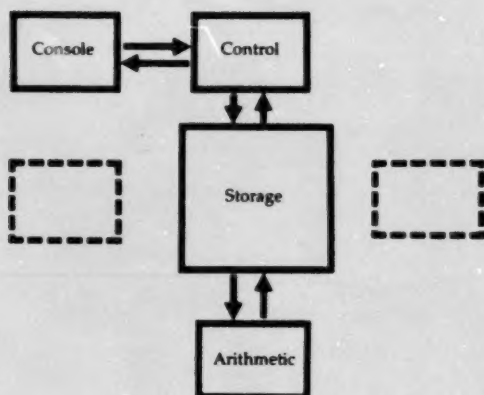


FIGURE 4
Central Processor (CPU)

A more complete schematic representation of a modern computer appears in Figure 5. The size of the main storage (memory) is much greater than the other units to emphasize the massive storage capabilities of computers today. The input/output devices may be a card reader, magnetic tape unit, terminals, magnetic disk, or scanner devices. Many input/output devices may be "tied" into a computer. These need devices called "data channels."

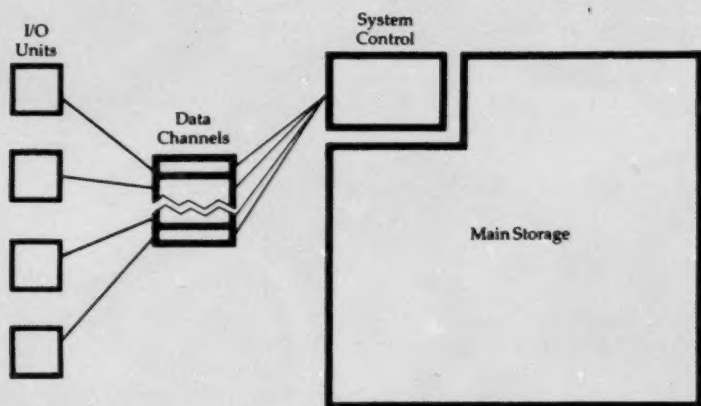


FIGURE 5
Multiaccess Digital Computer System

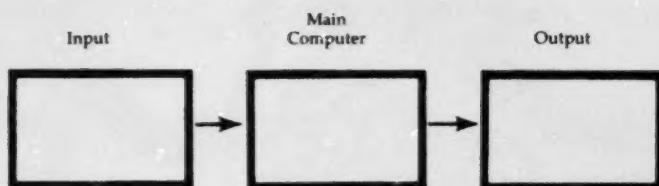


FIGURE 6
Generalized Computer System

In sum, computers are considered to be divided into three parts: an input unit which feeds information into the machine; the main computer; and an output unit which produces the information (Figure 6).

These sections work together to give the computer the ability to control its functions and to perform mathematical and logical operations. They are much more than just computational slaves because of their speed of calculation. They are information processors. They must be considered as machines which have reliable memories and, therefore, can be taught to play a reasonable game of chess or to keep a record of a student's learning pattern. They do this by remembering. They can "remember" every position they have seen before and also what move they then made. Computers are able to remember, but they cannot think, so they are entirely dependent on the people who run them.

Input

A computer cannot solve a problem or process any information unless it has the necessary facts or information. That part of the machinery which channels information into the computer is called the "input" section. The basic function of the input unit of the computer is to accept information and act upon it so that data can be used by the rest of the machine. This information must be in some regular coded form that can be sensed and converted into electrical impulses.

One method of supplying input data is by means of punched cards. The position of the holes in the card determine the type of character that is presented. The card image in Figure 7 indicates the various alphanumeric (Alphabetic-numeric) and special characters that can be punched on a card.

A punch card is a standardized means of computer input with regard to size and layout. In the card in Figure 7, there are 80 columns (left to right) and there are 12 fields (top to bottom). Thus, there are 960 distinct locations on a punch card. The keypunch machine is used to prepare the cards. The keypunch is comparable to a typewriter. An operator reads the source information and types it on a keyboard which causes the machine to punch the holes on the card.

As the punched cards are "read in," information, represented as a hole in a card, is converted to an electrical impulse usable to the computer. Some card reader units can read up to 2,500 cards per minute.

Information punched on cards may be converted by an independent device to magnetic tape, which is then used as the input to the computer. Data storage on magnetic tape is much more efficient and economical than data stored on cards.

Data input via a terminal is used on all microcomputers and many large computer systems. Terminals use a keyboard similar to a typewriter for input. Output may be a TV-like screen (cathode ray tube or CRT) or hard-copy (a paper printer). Many large computer systems are moving away from card input to on-line input using intelligent terminals (terminals which contain a microprocessor to maintain its functions). Such systems are faster and more efficient than punched card systems.

A convenient medium for input of data as well as storage of data is the magnetic disk. Physically, disks resemble phonograph records and are found in these versions: (a) the hard disk pack which can be removed from the disk drive; and (b) systems in which the hard disks are permanently attached to the drive unit. A popular variation is the "floppy disk" or "diskette" used with microcomputer systems.

In either case, the disk is a platter coated with a magnetic material which rotates much like a phonograph record. A read/write head resides very close to the surface of the disk and can be positioned any place along the radius of the disk, thereby retrieving or writing data. A distinct advantage of disks or diskettes is that they are fast devices with respect to the time required to store or retrieve data. Also they are random-access devices in that specific areas or content can be addressed by the computer.

Magnetic tape is also an efficient input and storage system. On a standard magnetic tape, 6,250 characters (about 78 punched cards) can be stored on an inch of tape and magnetic tape units can read this at approximately 200

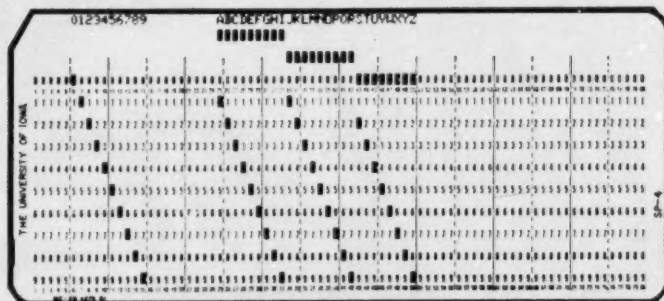


FIGURE 7
A Card Image

inches of tape per second. An additional advantage of storing data on magnetic tape is that it is highly compact, is durable, and is easily transportable. A 2,400-foot reel of tape is only about 10.5 inches in diameter and weighs only a few pounds. It could contain information which would require over a million punched cards.

Optical Character Readers (OCR) can read letters, numbers, and special symbols. The symbols to be read must be printed in a standardized format. Optical mark readers can read pencil marks on specific areas of a sheet. A sample of the simplest optically read mark is the pencil mark used to indicate answers on a test. Since these marks do not have to be converted by a human into another computer acceptable form, the speed with which data can be entered into a computer is increased.

Bar code readers accept data from documents or products inscribed with a special machine-printed bar or line code. An application which is increasing in usage is the utilization of the bar code (referred to as the Universal Product Code) in supermarkets and other retail stores. These bar codes are "read" by optical scanners, either hand-held or built into counters. The computer can price the item, update the inventory and print a receipt.

The replacement of the outdated cash register with electronic terminals allows users to do more than just calculate totals. As input devices, these terminals, often called point of sale terminals (POS), connected directly to a computer, update sales records, customer accounts, and sales records at the same time that the transaction takes place.

An ultimate input device would be one that recognizes human voice. While still in the developmental state, some computers can recognize some limited forms of human speech.

Storage or Memory

The storage or memory can be visualized as a large box divided into compartments, each containing information. This unit is like an indexed filing cabinet in which stored material is instantaneously accessible to the computer. The computer remembers; that is, it can store in its memory information. Each location, position, or section of storage is numbered so that the stored data can be readily located. The amount of information that can be held within the computer at any one time is dependent on the size or capacity of the storage unit. By means of numerical addresses, a data processing system locates data and instruction.

An older, outdated type of memory, core storage, consists of many magnetic cores, tiny, doughnut-shaped objects composed of a ferric material that can be readily magnetized. A core is no larger than the head of a pin. Running through the center of each core are two and usually three wires—two wires control the magnetization, and one determines whether the core is magnetized. Two wires determine the location of the core or define the plane in which the core is located. If a core storage area can be envisioned

as a slice of a cube divided horizontally and vertically, then any smaller cube can be identified by knowing the column and the row within the plane. The address label for each core can then be specified for any location. Present-day systems utilize semiconductor technology as a type of memory.

Data, as the name implies, are information elements needed to solve a problem, perform a calculation, or update student and teacher files. An instruction word is a computer word which tells the computer what to do. When both are in the main storage, instruction and problem data can be distinguished only when they are brought into the CPU. During the instruction cycle, it is interpreted as an instruction; during the data cycle, it is considered as data. If information is placed in storage so that data are available during an instruction cycle, the computer treats the data like an instruction. This allows the computer to change its own instructions if these instructions are placed in storage during the data cycle.

Primary storage is the area in which data and instructions are kept within the CPU. Primary storage may be compared to a large erasable blackboard; an area for saving data but one which can be erased and used again. Primary storage is used to hold the instructions related to the program which is currently being run and other data needed for that program.

A large part of the data which the computer may need is stored in an auxiliary storage device, and pieces of that data are transferred to primary storage when necessary. Auxiliary storage devices include: magnetic tape, hard and floppy disks, magnetic drum, bubble memory, laser, and charged-coupled devices.

In general, primary storage devices can be divided into random access memory (RAM) and read only memory (ROM). RAM memory devices are more flexible; data may be written into RAM memory and read out again. When the data are no longer needed, they may be erased and replaced with other data. RAM memory is "volatile," and the contents are lost when power is turned off.

In ROM devices, data may be read only. Data or programs are permanently written into the device during manufacture. Loss of power does not affect the contents of ROM memory.

Control Unit

The control unit directs the operation of the other units. It directs the flow of information in and out of the computer, as well as manipulating information inside the computer. It coordinates and programs the functions of the various parts of the computer. It obeys our instructions exactly. It works like a clock and ensures that selected events occur at just the right time in relation to other events. It takes care of carrying out the instructions given to the machine and of executing the sequence or program of instructions. The list of instructions is called a "program." The control register (a device for storing a piece of information) in the control unit contains the current

instructions for the machine at each cycle or step. Instructions tell from which register information is to be taken, which register is to receive information, and which register contains the next instruction to be executed. The machine needs only the position of the first instruction; given the information, it automatically executes a series of instructions.

Arithmetic and Logic

The functions of the arithmetic/logic unit are to perform calculations and make comparisons. It is composed of registers, analogous to the gears and wheels of a desk calculator, where numbers are entered and results are shown. It can add, subtract, and multiply in a manner similar to a desk calculator, but at a much higher speed. In addition to doing arithmetic, the computer can perform logical operations and distinguish between positive, negative, or zero values. It can compare two items at a time, eliminate one item, compare the remaining item to a third item, and repeat the process. Instructions allow the computer to compare two numbers, find out if one is larger than, smaller than, or equal to the other. These latter instructions are rules of Boolean algebra. These decision or branch statements are represented in mathematical notation as:

- < less than
- > greater than
- = equal to
- ≤ less than or equal to
- ≥ greater than or equal to
- ≠ not equal to

The various registers in the arithmetic unit not only enable arithmetic (logical) operations, but can store information as well. Instructions written by the programmer or those logical sequences permanently stored in the computer can be used to "tell the computer" what operation to perform and what to do with the results. As an example of an arithmetic operation in the language of computers, consider the addition of two numbers. The numbers to be added are located in separate addressed locations or register numbers. The operations could be written as below:

INSTRUCTION	CONTENTS OF NAMED REGISTER
AR 3,5	+ 47
AR 3,6	+ 52

These two instructions perform the following operations: AR 3,5 instructs the computer to take the contents of general register 5 and place them in register 3. The next instruction, AR 3,6, instructs the computer to take the contents of register 6 and add them to the contents of register 3. The result is that the number + 47 is taken from register 5 and placed in register 3, then

+ 52 from register 6 is added to + 47 to yield + 99 in register 3. This step-by-step series of operations done in microseconds demonstrates the basic operations accomplished within the arithmetic unit of a computer.

Output

The information is produced at an output device in human and/or machine readable forms. Punched cards, magnetic tape, magnetic disks, terminals, and high-speed printers are common output devices. The same signals that are normally directed to a high-speed printer may be used to operate valves, motors, and controllers in an automatic industrial process. Examples of such processes are: digitally controlled machine tools, automatically controlled gasoline refineries, steel and chemical plants.

Printers may be divided into several classifications and may be grouped into impact printing devices or nonimpact printing devices. Those printers which print characters by striking the surface of paper with a type hammer—such as those that are found in a typewriter—are classified as impact printers, while those which work on thermal, chemical, photographic, or laser principles are classified as nonimpact printers.

Among the group of impact printers are those similar to typewriters which strike a ribbon against paper. Many have interchangeable type elements such as type ball or daisy wheel. Other impact printers utilize a matrix printing device in which a group of wires or rods is typically arranged in a 5 by 7 matrix pattern in a moving print head. Characters are formed by striking a ribbon with selected pins against paper.

High-speed impact printers include chain, wheel, and line printers which print an entire line of output at one time at speeds up to 2,500 lines per minute.

The nonimpact printing devices include electrostatic printers which utilize coated paper which darkens in those places where an electric charge is applied. Voltages are applied to form the desired characters as the print head passes over the paper. The high cost of the special paper required often discourages use of this method.

Photographic printers utilize a beam of light focused through a rotating disk containing a full font of characters. The image of a character is projected onto a piece of photographic paper through a series of lenses. The paper is then processed similarly to photographs.

Electrographic printers use lights, lenses, and electronics to form images that can be printed on ordinary paper. Laser printers utilize laser technology to produce copy in a manner which may be roughly compared to the process utilized in office copiers. This type printer can print at speeds up to 20,000 lines per minute.

One method of output which is utilized to reduce the amount of physical storage of printed materials is to produce output in the form of microfilm or microfiche directly from the computer. Computer Output Microfilm

(COM) machines can produce the equivalent of 14,000 lines of data per minute.

A plotter is an output device which can connect the electrical impulses from the computer into line drawing of varying complexities. Plotters can produce many different kinds of charts, graphs, diagrams, patterns, and architectural drawings.

Output from computers may also be displayed on display terminals where the output appears on the face of a cathode ray tube (CRT), which is actually a television screen. These terminals are frequently used as both input and output devices.

All modern digital computers consist of these five functional components. The differences between digital computers are the capacity of the memory, speed of the arithmetic unit, and the number, variety, and speed of the input and output units.

Microcomputers

The microcomputer was first introduced in the mid-1970s. The basis of the microcomputer is the microprocessor, a silicon chip containing the necessary circuitry to perform arithmetic/logic operations and to control input/output operations. The microprocessor is a very complex electronic circuit, consisting of thousands of transistors squeezed onto a tiny chip of silicon that is often little more than three or four millimeters square. The chip is then packaged as a single integrated circuit containing approximately 40 leads of contacts. By adding input/output devices and a memory to the microprocessor, a microcomputer is formed.

Early microcomputers offered a limited processing potential and an even more limited choice of input/output devices. Today, however, these devices have grown in size and processing capabilities and support a wide range of input/output devices. Microcomputers are currently available with a wide selection of input/output devices from tape cassette recorders to a voice synthesizer. In addition to being used as a general-purpose computation device, microprocessors have been incorporated into automobiles, airplanes, toys, clocks, and appliances.

Section 5

THE LANGUAGE OF THE COMPUTER

While most of us are amazed at the ability of the computer to solve seemingly impossible problems, it is important to remember that the same computer is incapable of doing anything unless specifically instructed by a person. This person, called a computer programmer, may spend hours analyzing and defining a problem in order to prepare a set of instructions that the computer can follow. To accomplish this task the programmer must have the necessary knowledge to solve the problem without the aid of the computer.

The instructions prepared by the programmer comprise the computer program. The instructions in a program must be detailed and precise. They must follow a strictly logical flow so that the computer can arrive at accurate, correct results. It may take many different computer programs to solve one task. The beauty of the computer program is that once it is written it may be used over and over again to solve similar problems. In other words, a computer program may not be written to solve one problem but is usually written in a general sense so that many problems of similar nature can be solved with the same program.

These programs comprise the computer function commonly known as software. Milton Wessel in his book, *Freedom's Edge*, defines software in this way: "Computer software includes the instruction which enables the computer's physical equipment (Hardware) to do the work. Without it, most computer hardware is just a mass of inanimate wire and metal; with software, the machine comes to life and begins to produce its output."

Each computer program is made up of instructions. The instructions must be precise and simple, and must provide the computer with exact information. A typical instruction will consist of two parts. The first part, the operation code, tells the computer what to do—add, subtract, multiply, divide, and so on. The second part, the operand, tells the computer how to do it or on what to operate. The operands may contain actual data or may contain a memory address of actual data. Generally, there are three different types of instructions. These include (1) input/output instructions; (2) arithmetic instructions; and (3) branch instructions.

Let us examine each of these for a moment. The input type of instruction directs the computer to accept data from a specific input device and store it in a specific location in storage. Output instructions tell the computer to move a piece of data from a storage location and record it on the output medium.

The arithmetic instructions simply direct the computer to perform one of the basic arithmetic functions, i.e., addition, subtraction, multiplication, division.

Branch instructions cause the computer to alter the sequence of instruction execution within a program. Normally the flow of a program is linear with the instructions executed in sequence. The branch instruction interrupts the sequence and directs the computer to execute an instruction in a different order. The branch can be one of two different types. The unconditional branch always executes the branch, regardless of existing conditions, and the conditional branch executes the branch only when a given set of conditions are satisfied.

Programming languages, the primary means of human-computer communications, have evolved from the early stages where programmers entered instructions into the computer as binary numbers which set a large number of on-off switches, to programming languages which allow a programmer to enter instructions into the computer in a language similar to that used in the application.

There are many different programming languages. Perhaps the most widely used are assembler language, COBOL, FORTRAN, RPG, PL/1, Pascal, and BASIC.

In general, programming languages can be classified as machine-oriented or problem-oriented languages. A machine-oriented language is one that corresponds to the instructions of the computer. In contrast, problem-oriented languages are designed so that they can be used to solve various types of problems. For instance, FORTRAN was designed to solve scientifically oriented problems.

Of course, the computer only understands a language called machine language, that is a language which uses binary coded numbers. Because of this requirement it is necessary that a program written in a source language like FORTRAN, COBOL, etc., be translated into machine language. The process known as compilation is done by the computer by running the program through a compiler. The compiler is a computer program which converts the source language program into machine language.

The rest of this chapter will be devoted to a description of the common languages and a discussion of the advantages of each. Also a comparison of the languages will be offered.

Assembler Language

Technically, it would be feasible for a programmer to write machine language code. Certain systems programmers may still do this regularly. The instructions would take the form of arrays of hexadecimal (base 16) digits with each field or group of the hexadecimal numbers being a significant area of computer memory or a specific direction to the computer like: ADD, SUBTRACT, COMPARE, MOVE. While this is technically feasible, it is not

very practical. The complexity of the programming would occupy the programmer to the point where the complexity of the job to be programmed would be limited.

The advantage of the machine language program is that the programmer maintains control of all functions of the computer. The programmer allocates memory and decides the priority of operation. The advantages of Machine Language can be maintained but somewhat simplified by using an assembler language.

Assembler language is a "symbolic machine language." Instead of arrays of numbers, the programmer uses a symbol which more closely resembles the function. An example would be a symbol like MVC which stands for Move Characters.

A comparison would be to add two numbers that have been input to the computer. On an IBM 370, in machine language the instructions would look like this:

F2 24 F068 E05E

F2 24 F068 E063

F8 22 F100 F068

FA 22 F100 F06B

In 370 assembler language, the same thing would be accomplished in this way:

PALK ONHAND, IONHAND

PALK ONORD, IONORD

ZAP AVAIL, ONHAND

AP AVAIL, ONORD

One can easily see that the assembler language instruction more closely represents an understandable representation of what is occurring.

In general, each computer has its own assembler, and hence, its own assembler language. For instance, the Hewlett Packard 3000 and the IBM 370 both have an assembler language. Because they correspond to machine capabilities, assembler languages for two different types of computers are not the same.

The assembler language is an improvement over machine language since it enables the same degree of control over the computer and is much easier to use. However, for most applications assembler language is still an intricate and in many respects cumbersome way to develop a computer program. Most programmers use a higher level language such as those discussed below.

COBOL

The other languages discussed in this chapter are all problem-oriented ones. COBOL which stands for Common Business Oriented Language was first introduced in 1960 and is one of the oldest problem-oriented languages. As the name indicates, it was designed for business use. The major

distinguishing feature of the business-oriented language is the ease that it allows in developing the output forms that are so important in business-oriented problems.

The same example used above written in COBOL would look this way:

ADD ON-HAND ON-ORDER GIVING AVAILABLE

Notice that COBOL uses terminology that would be understandable to the layman. Another major enhancement is that COBOL has been standardized, thus eliminating the difficulty with compatibility that was discussed in the section on the assembler.

In an attempt to make COBOL a standard language, the American National Standards Institute (ANSI) published specifications for standard COBOL in 1968. Theoretically, if all COBOL compilers conformed to these specifications, it would be possible to take a program written for one computer, make a few modifications and recompile it so that it would run on another computer. In 1974 a revised version of the standards was published in an attempt to get closer to the goal of total transferability. It is expected that further revision is forthcoming in the early 1980s.

In fact, to date, even with these efforts there is no such thing as the transfer of the COBOL language from one computer to the next. This concept nevertheless has set standards which aid the programmer in that learning COBOL for an alternate machine is a relatively simple task.

FORTRAN

The acronym is for FORMula TRANslation and the language was designed with that in mind. The emphasis in FORTRAN is in scientific applications. Whereas COBOL allows for the easy design of output forms, FORTRAN allows for rapid calculations of intricate scientific formulas.

The above problem in FORTRAN would look like this:

AVAIL=ON HAND + ONORD

The equation

$$X = \frac{(A + B)(A - C)}{(B + D)}$$

is written this way in FORTRAN:

$$X = ((A + B) * (A - C)) / (B + D)$$

One can readily see the close relationship in format between the algebraic notation and the FORTRAN notation.

FORTRAN is available on computers of all sizes ranging from the micro-computer to the very largest of systems. As with COBOL, the American National Standards Institute published FORTRAN standards. These have been more successful than the COBOL effort and FORTRAN does not differ significantly from computer to computer.

PL/1

In 1966 IBM developed a new programming language called PL/1. The language was intended to combine the business capabilities of COBOL with the numerical manipulative advantages of FORTRAN.

When the language was introduced, many felt that it would replace COBOL and FORTRAN. These predictors seemed to envision a host of other computer manufacturers to develop their own PL/1 compilers. This in fact has not happened. There are far fewer users of PL/1 compilers than of either FORTRAN or COBOL.

Here is the sample code in PL/1:

Available=ON-HAND + ON-ORDER

BASIC

BASIC, which stands for Beginners' All-purpose Symbolic Instruction Code, was developed at Dartmouth College. It is available today on a wide range of computer systems and, in fact, has become the dominant language of the rapidly growing microcomputer field. Virtually every microcomputer uses BASIC as the primary language. Originally designed as a time-sharing language, BASIC now incorporates most of the functions of FORTRAN. Because of the ease in learning the language, it has gained much popularity.

Our sample code would look like this in BASIC: LET A=B + O

Summary

The evolution of computer languages from lower to higher levels, and the development of a wide variety of problem-oriented languages has been one of the most important software accomplishments. In fact, if programmers still had to do all the programming in machine language, there is no doubt the computer would not have grown as rapidly as it has. Not only is programming easier in the areas of business and mathematics, but also in areas such as medicine, the arts and humanities, linguistics, and the other social sciences where special languages have been developed using vocabulary common to the problems being studied. Consequently, people from many diverse disciplines can now easily use the computer as a problem-solving tool. With the advent of languages such as BASIC and Pascal, programming instructions can be given in a form very similar to a natural language like English. Many computer scientists and social scientists believe that once computers can be programmed in a natural language, perhaps just by using voice input, there will no longer be any barriers to a mass domestic computer market, that is, a computer in every home.

Section 6

ADMINISTRATIVE APPLICATIONS OF THE COMPUTER

Much of administrative data processing is now becoming routine. Most large colleges and school districts began to make use of computers for administrative purposes in the 1950s. The early applications included budget/accounting, payroll, student scheduling, grade reporting, and inventory listing. The scope of the applications has steadily increased, and a general listing of administrative applications is outlined below.

Student Applications

1. Student Scheduling
2. Grade Reporting
3. Grade and Transcript Information
4. Daily and Summary Attendance Accounting
5. Student and Family Demographic Information
6. Health Records
7. Instructional Management
8. Test Scoring and Summary Information
9. Tuition and Fee Statements

Personnel Applications

1. Payroll—checks and deductions
2. Personnel Records
3. Staff Assignments
4. Certification Records
5. Health Records
6. Tax Information and W-2 Reports

Financial Applications

1. Budget/Accounting
2. Accounts Receivable/Payable
3. General Ledger
4. Purchase Order Generation
5. Salary Schedule Analysis and Forecasting

Facilities/Equipment

1. Room Locations/Capacities
2. Room Assignments/Utilization
3. Equipment Inventories
4. Maintenance Scheduling
5. Energy Utilization/Control

Research/Planning Applications

1. Budget Forecasting
2. Bus Routing
3. Statistical Analysis
4. Test Item Analysis
5. Project Planning/Evaluation (PERT/CPM)

Office Applications

1. Filing Systems
2. Word Processing
3. Mailing Lists and Labels

Library Applications

1. Bibliographic Information Retrieval
2. Circulation
3. Cataloging
4. Purchasing

This listing and categorization is certainly not exhaustive, but it is illustrative of the major and typical administrative applications. Local and state requirements may dictate a range of additional applications and reports.

Data Base Management Systems

Many large computing centers employ the use of a data base management system (DBMS). This is a generalized computer program which allows the school district or college to enter a range of data elements and which provides an easier means of producing required reports than would be the case if separate applications programs needed to be written for each desired report. The use of a data base management system does not guarantee that a user's need for information can be met immediately or even in a day or two, but it does enhance the ability to integrate and report information in a timely and cost-efficient manner. Routine reports can be programmed in the report generation language of the data base management system and run daily, monthly, or annually, as required. Individual requests for information can be programmed and run as required, provided that the necessary data elements already are in the data base, that there is sufficient time to write and run the necessary program, and that the value of the information justifies the cost of providing it.

Management Information Systems

A lot has been written and said recently about the design, development, and use of management information systems (MIS). There is much to say and learn about this topic, and all that will be presented here is a brief discussion of the term. Managers are decision makers. In an educational setting administrators, counselors, teachers, parents, students, and others may be viewed as essential decision makers as they consider matters of consequence to the total organization, a unit, or the education of an individual student. Each makes a variety of decisions at the day-to-day operational level, or monitors the performance or work of others, or plans for the next steps or goals which need to be undertaken. Management information systems are designed to provide information which is useful to a decision maker in selecting an alternative course of action which in some sense is best. For example, it minimizes cost; it maximizes achievement; it provides for increased educational opportunity. Management information systems are not always or totally computer based, though many are. The concept is one of providing useful, timely, and cost-effective information to decision makers rather than being equivalent to a computer system.

New Administrative Computer Systems

While the scope of administrative applications has increased steadily over the last three decades, the last few years have seen a fundamental change in some aspects of this important applications area. These changes are a direct result of technological developments in the areas of computer networking and microcomputers. There is little need to discuss the impact of microcomputers; already they are ubiquitous. The presence of microcomputers at the departmental or building level allows for the collection of information and the generation of reports at this level (such as attendance reporting, accounting, and instructional management), more timely, more comprehensively, and less expensively than has been possible heretofore. Additionally, school or department-based computers allow for locally responsive applications to be handled which would not have been feasible before, such as keeping track of local student activity accounts. Through networking, or the linking of computers together, it is possible to transfer data from one computer to another. Networking provides two advantages to the school or department. It can send or receive desired data or information without first having to transfer the information to printouts, cards, tapes, or disks. This improves the speed, accuracy, and probably the cost of data transfer. Therefore, for example, student and faculty attendance information could be transferred directly to the district office or the state in the form desired without the intermediate step of preparing, perhaps typing, and sending a written report.

Secondly, but related to the first, is the ability to transfer data to a larger computer for processing and then return the information or report to the

schools; for example, the schedule of a newly assigned or enrolled student. Computer programs for school or department-based applications and for networking are becoming available in the commercial sector, and these capabilities represent a powerful tool for the future, as well as a new era in administrative computer applications.

Software

While the development and acquisition of software are important and timely topics, an attempt will be made here to summarize the major points. Fortunately, things are looking up; for some time, a range of applications programs has been available from software houses, computer hardware vendors, and other users of similar hardware, to run on large computers. There has been a problem in finding adequate programs for smaller computers and microcomputers. Although the need for quality programs at affordable prices still exists for large computers, the problem is not as acute as for the smaller ones. But considerable development is under way, and much software is becoming available for a variety of microcomputers. When considering the acquisition of software, users need to develop their own set of criteria regarding what the program should do and what it is worth to acquire a software package which will do it—what reports, information, instructional objectives, etc., are to be met, if the program can do it, and at what cost. When possible, you should contact current users of the program who use it on similar hardware and seek a trial period before purchase, or at least a demonstration of the program on your system. Determine if there is a guarantee for the system. You should set up a formal evaluation process, for the acquisition of computer software, whereby you can assess formally the administrative or pedagogical value of the program. If possible, you should include a way for potential users to try it out. The program should, of course, be well documented; that is, it should be clear how to get it to run on your system and how to use it. If the program is to be run by students, you want to be especially attentive to what happens if erroneous input is placed into the computer, as will happen with unknowledgeable users, through carelessness or attempts to test the sophistication of the system. You want to be certain that a support system exists if you do have problems, and last, but quite fundamentally, is the program worth the price you have to pay for it? In other words, is there a less expensive way to accomplish your objectives, or is the software vital to your overall goals? In general do not design and build your own system unless you have no alternatives, which is becoming less and less the case.

The Data Processing Center

Who are all those people who work in a data processing center, and what do they do? While the job descriptions and organizational arrangements vary from school district to school district and college to college, there is

considerable similarity. What is presented here is typical, but in no way meant to be optimal or exemplary. An organizational arrangement for administrative data processing might appear as below.

The organization chart displayed in Figure 8 contains three major divisions: Development, Operations, and Maintenance. The director, who might have a title such as assistant superintendent for computing or director of data processing, has overall responsibility for meeting the administrative (and perhaps instructional) computing needs of the district. Reporting to the director might be managers of the three areas referenced.

Also reporting to the director may be an accounts manager, who assigns account numbers, passwords, and access codes, and depending on how accounting is handled in the organization, keeps track of budgeting and accounting information concerning computer use. Additionally, bookkeeping, purchasing, clerical, and secretarial personnel would be required to carry out the functions of the computing center.

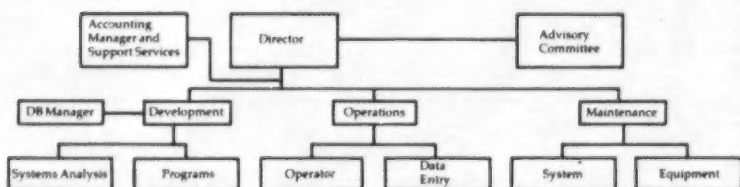


FIGURE 8
Organization Chart

Advisory Committee

Many computer center directors find it desirable to establish an advisory committee to assist them in identifying problems and setting priorities for program development and modification. Additionally, such a committee can assist in carrying information back to user groups from the computer center. Such a committee also may be useful in recommending policy for center operations. The composition of the committee might vary depending on the need of the director in a particular organization, from staff members to high-level district or college administrators.

Development

The development area is concerned with new applications and the modification and enhancement of present applications. The development group is charged with finding the most cost-effective means of meeting established needs, whether through development, modification, or outright purchase or lease. The manager of this area is responsible for determining what computing needs exist within the district and, together with the director and advisory committee, decides what priorities exist among the needs. Systems analysts work with the users of the computer system to define the information needs and design computer systems, including computer programs, which will meet those needs. The system designed must take account not only of the computer programs to be developed, but also the people involved, their work setting, attitudes and values, equipment, and costs; that is, all factors which will be affected by the application. The failure of many computer applications can be traced not to a poor computer program in a technical sense, but the failure to work with the users and to consider the total system.

Also involved in the development area are the programmers, the personnel who actually translate that portion of the system design which will be performed on the computer into a form which can be carried out by the computer. A computer program is a set of instructions which can be interpreted and carried out by a computer to accomplish a desired outcome, such as the generation of a report or the storage of certain information. The third unit listed in this division is the data-base manager. Typically this is an individual, not a group, who serves an essential purpose. The many reports required by colleges and school districts frequently are based on the same basic data elements: student, personnel, facility, budget, and equipment information. The data-base manager is responsible for seeing that data elements are stored only once and that there is a fixed method and responsibility for updating that element. We want to avoid, for example, having several personnel files containing the name of each teacher, their school, experience, salary, certifications, and all of the other information which someone might desire. We also want it clear as to who has the authority or responsibility for seeing to it that information in the data base is correct and current. The data-base manager then sees to it that each data element is included only as needed and not duplicated, and that someone, a single person or office, is responsible for ensuring the accuracy of the data from entry through deletion. Further, this individual needs to ascertain which items are fundamental and which are secondary or derivations; that is, if an element can be calculated from other elements then it may not be necessary to include it in the data base. In many cases the cost of storage of information greatly exceeds the cost of computing it. So, for example, the cost of storing a cumulative grade-point average may be far greater than computing it from individual student grades.

Not all applications need to be developed; there are a large number of application programs available through computer manufacturers, software houses, and other educational organizations. The development division needs to examine alternatives in addition to local development to meet identified needs. Increasingly, solutions already exist which will satisfy the needs of the organization.

Whatever the origin of a system, it is the responsibility of the development division to be certain that it works, that it produces the reports specified, that it yields the results desired. The system, both the human and machine components, must be tested and certified prior to passing it along to the operations division.

Operations

This group is charged with ensuring that all regular administrative computer jobs are scheduled and run so as to meet the needs and responsibilities of the college or district. Scheduling can be a major problem, particularly as the computer resources become scarce—that is, as the work which needs to be run on the computer approaches the work capacity of the system. The jobs must be scheduled so as to be completed on time, but also so as to make maximum use of computer resources. Most large computer centers operate 24 hours a day and as many as seven days a week. If there is a time when the computer is not used fully, some attempt could be made to sell this time to other educational and nonprofit organizations.

In addition to the scheduling of production work, the major functions within the operations division are machine operation and data entry. As the name suggests, machine operators are those individuals who actually run the computer, enter programs, receive printouts, mount computer tapes, change computer disk packs, and monitor the operation of the computer. Usually, there is a very experienced operator who acts as a shift supervisor. Except for the supervisor, and contrary to the expectations of many, machine operation does not require a high level of formal training and most machine operators are trained in vocational centers, two-year community colleges, or on the job. These individuals typically cannot program the computer and are able to handle only minor problems which may occur during machine operation.

Data entry is responsible for seeing that data needed for production runs are accurately placed into a form which can be used for input into the computer. In most cases, this involves a keyboard operation, such as keypunching cards or "typing" information onto a magnetic tape or disk in so-called key-to-disk and key-to-tape operations. The cards, disks, and tapes are then used for data entry as the production schedule demands. Only on rare occasions in large computer operations will data be entered directly from a keyboard into the computer. With all keyed entry, great emphasis must be placed on the accuracy of the process, and, typically, a verification step

is used wherein the data are entered and then reentered or rekeyed to ensure its accuracy. Many computer programs also check or verify data as it is input to catch obvious errors, such as dollar amounts which are excessively large, and illegal codes such as "T" if "F" and "M" are the only legal codes for sex. As can easily be imagined, an error in input can cause a great many problems in reports which are generated.

The concern for accuracy (and also for speed) has led to considerable emphasis on "source document entry," that is, the use of the actual forms or papers which are produced in the normal operation of a unit for entry into the computer. Some examples are "mark sense" answer sheets for tests and the magnetic codes on checks. All that the bank codes on checks as they are returned for processing is the amount—the bank and the account number are preprinted. Grocery and department stores are using scanners to read the universal product codes printed on items to save the keying process and thereby improving accuracy, saving time, and maintaining a "real-time" inventory. It is likely that a heavy dependence on keyed entry will continue for many years to come, but source document entry should be utilized whenever possible and justified; this may include voice recognition, as a considerable capability for direct voice communications with computers already exists, as do some commercial applications of this technology.

Maintenance

While this division may be housed within the operations group or otherwise linked organizationally, its function is vital to the effective operation of the computer center. Two major units are included within this division: systems programming and hardware maintenance.

The development of applications programs, those that serve the direct needs of administrators, teachers, and others within the educational setting, is located in the development division. Every computer also utilizes another program called the operating system. This is the controlling program for the computer. It maintains order, keeps track of the various programs which run on a computer and their input, files, and output. Systems programmers maintain the operating system; they diagnose and fix problems with this system, upgrade and enhance it, and periodically modify it as specified by those who developed the operating system, frequently the manufacturer of the computer hardware. Typically, there are fewer systems programmers employed in a computer center than applications programmers, but their function is just as vital. While the roles of applications and systems programmers are different, some individuals have expertise in both areas.

While major problems do occasionally occur with computer hardware, the number of these problems can be reduced through routine maintenance, and computer centers frequently schedule maintenance on a daily

and weekly basis. Mechanical equipment, such as printers, requires frequent and regular maintenance, while totally electronic components, such as the central processing unit of the computer, rarely experience problems. Computer programs have been written to assist in the diagnosis of problems in the computer system, both hardware and operating system problems.

Many computer centers contract with the hardware manufacturer or private firms for all or part of their maintenance, rather than maintaining a large full-time staff, but many have a limited in-house capacity for hardware maintenance.

Section 7

OFFICE AUTOMATION

Nowhere are the advances of modern technology more evident and the implications more far-reaching than in the area of office automation. Think back about the office of the turn of the last century. A typical office contained no telephone or dictation equipment. But since the widespread implementation of this equipment, about 50 years ago, the basic structure of the office has not changed greatly. Typically, too, most interoffice communication has taken place in written form by way of public mails or private courier service. But the world of the office worker is changing dramatically as a result of microprocessor and microcomputer technology and the use of computer networks.

Most of what office workers do will remain the same, but the way they do it will change markedly. A large number of word processors are currently being marketed, and, in addition, programs which operate on all but the smallest microcomputers can make these computers perform word processing applications. Word processors are in a general sense intelligent typewriters, but they are capable of much, much more. Word processors store textual and tabular material, making it easy to modify the material without manually retyping the entire text. They also make it easy to change a portion of the text for use for a different purpose, such as sending a letter to a different person, reformatting a proposal for submission to a different group, or updating an annual report from one year to the next. Additionally, the word processor can assist in the generation of a new report which might be drawn from several existing reports. The required material can be drawn together from disk storage, compiled, modified, and printed at a great saving in time for both the administrator and the secretary.

Word processors can provide a large number of other advantages including automatic pagination, ease of error correction, checks of spelling, left and right margin adjustment, and hyphenation.

Intra- and interoffice communication also is changing as a result of computer-based technology. Such concepts as shared-data bases, transfer of information on tapes or disks, and direct electronic transfer of information through computer networks are examples. It seems such a shame and a waste of time and money that so much of the information that we maintain on students, teachers, and other matters is collected and stored repeatedly. By sharing data bases and by transferring information electronically, we can cut down greatly on the amount of information actually stored, the accuracy of that information, and the ease by which it can be accessed. For

example, detailed student attendance information could be collected and stored at the building level, transferred in aggregate form to a school district central office, and summarized further for transmission to a state agency as needed to satisfy requirements, but there is no reason that any of this transmission or storage, following initial data entry, needs to take place in printed form.

Data entry remains a major problem in office operation. All of what has been said above depends upon the initial entry of information. For a long time to come, much of this entry will be through keyboards such as those on common typewriters. Using a special type font on a regular typewriter, a typed page can be generated which can then be read by an optical scanner. Much data entry, in time, will be entered directly from source documents and therefore not require the intermediate step of keyed entry. This is good both from the standpoints of cost and accuracy. Mechanisms for source-document entry include sheet scanners, mark-sense card readers, magnetic and optical codes (such as those on grocery products and checks), and voice recognition. As examples, attendance reports could be scanned optically and capital equipment could be coded optically or magnetically for source entry.

What will the office of the next few years look like? It will contain word processing equipment, scanning equipment, a telephone, perhaps dictation equipment, probably not a separate typewriter, fewer file cabinets, and a lot less paper. It will be neater, cleaner, and potentially considerably more efficient and less expensive to operate.

Appendix

COMPUTER TERMS

- ABACUS** A counting frame originating in the Orient more than 5,000 years ago, still used in many Eastern countries for performing arithmetic operations.
- ACCUMULATOR** A manipulative register, located in the arithmetic unit of a computer, where data may be held, operated on so as to perform various mathematical operations, and otherwise manipulated.
- ACOUSTIC COUPLER** A form of modem which permits attachment of an ordinary telephone handset so that a computer can communicate over any telephone.
- ADDRESS** An identification, such as a name, label, or tag, represented by a number or another set of symbols, that specifies a register, location in storage, or other data source or destination.
- ALGEBRA, BOOLEAN** An algebra of classes and propositions, like ordinary algebra, but dealing with truth values as variables and having basic operators such as AND, OR, NOT, EXCEPT, and IF . . . THEN.
- ALGOL** (Algorithmic Language; Algorithmic Oriented Language). An algebraic and logic language used by many computer groups as a common international language for the precise presentation of numerical procedures in a standard form to a computer.
- ALGORITHM** A process that may be carried out according to a precise prescription or problem. A description, leading, under fixed or variable conditions, to a definite result.
- ALPHANUMERIC** A contraction of alphabetic-numeric, a set of characters including letters, numerals, and usually a set of additional special symbols used as punctuation marks, special meaning marks, etc.
- ARITHMETIC/LOGIC UNIT** That portion of the hardware of an automatic computer in which arithmetical and logical operations are performed.
- ARRAY** A list of numbers or strings, the elements of which can be referenced by their position in the list.
- ASCII** (American Standard Code for Information Interchange). A standard code that assigns specific bit patterns to each sign, symbol, numeral, letter, normally found on a keyboard.
- ASSEMBLE** To translate a symbolic language program into a machine language program by substituting absolute operation codes and addresses for symbolic operation codes and addresses.
- ASSEMBLER** A computer program that translates a symbolic language program into a machine language program which then may be directly executed by the machine.
- ASSEMBLER LANGUAGE** A computer programming language very near to the machine language but using symbolic operation codes and addresses—see Assembler.

- ASYNCHRONOUS** A mode of operation such that the execution of the next instruction or the next event is initiated by a signal that is generated upon completion of the previous command or event.
- AUTHORS** Those who design instructional material for presentation by the computer.
- BASE** A number base—a quantity used implicitly to define some system of representing numbers by positional notation—radix.
- BASIC** An acronym for Beginner's All-purpose Symbolic Instruction Code—a general purpose computer language.
- BATCH PROCESSING** A way of using a computer whereby a set of programs is processed as a group during a particular machine run.
- BINARY** Having just two possible states or conditions, such as "on" or "off"—or "1" and "0."
- BINARY NUMBER SYSTEM** A numbering system used internally by computers that uses the number two as a base (as opposed to the decimal system that uses the number ten).
- BIT** A binary digit; a unit of information content—it is the smallest unit of information in a binary system of notation.
- BLOCK DIAGRAM** A graphic representation showing the logical sequence by which data are processed.
- BOOTSTRAP** A procedure for initiating the reading of a program by a computer.
- BUFFER** A device within a computer that serves as a temporary memory. It collects and holds the incoming data and delivers them to the processing unit when needed.
- BUG** A mechanical, electrical, electronic, or logical defect in a piece of equipment or in its operation, or a defect or error in a coded program; thus, a malfunction or a mistake.
- BYTE** A term to indicate a measurable portion of consecutive binary digits (bits); e.g., an 8-bit or 6-bit byte; a group of binary digits usually operated on as a unit; usually represents one alphabetic or numeric symbol.
- CAI PROGRAMMING LANGUAGE** A language used by authors to "tell" a computer to display a lesson, receive and process responses, and for branching to appropriate portions of the lesson as required by the logic of instruction.
- CALCULATOR** 1. A device capable of performing arithmetic. 2. A calculator as in (1) that requires frequent manual intervention. 3. Generally and historically, a device for carrying out logic and arithmetic digital operations of any kind.
- CASSETTE STORAGE** The storage of information on ordinary cassette tape. This type of storage is used by many microcomputer systems.
- CENTRAL PROCESSING UNIT** The group of components of a data-processing system that contains the logical, arithmetic, and control circuits for the basic system.
- CHARACTER** A letter, digit, punctuation mark, or other symbol used in the representation of information.
- CHIP** A single device, containing integrated electronic circuit components (usually silicon).
- COBOL** (Common Business Oriented Language). A business data-processing language designed to express data manipulation and processing problems, in a precise and standard manner.

- COMPILER** A program that converts a high-level programming language (source language) into machine language before the program is executed.
- COMPUTER-ASSISTED INSTRUCTION** A method of using a computer system as a means of presenting individualized instructional material.
- COMPUTER-MANAGED INSTRUCTION** The use of the capability of the computer to record the progress of a student through a learning sequence, providing guidance and control as dictated by the needs of the situation.
- CONDITIONAL BRANCH or CONDITIONAL TRANSFER** A branch (or jump out of the normal execution sequence in a program) which is only executed if certain conditions are met.
- CONSOLE** The part of a computer that is used for communication between the operators or service personnel and the system. The console usually contains a panel for lights, keys, switches, and related circuits for man-machine communication.
- CONTROL** The part of a computer which directs the operations of all the other parts of the computer.
- CPU** An abbreviation for Central Processing Unit—the part of a computer system containing the arithmetic, storage, and control units.
- CRITERIA** A standard or established level of attainment which must be reached by the student.
- CRITERION REFERENCED TESTING** A testing situation in which a student is evaluated on how well he achieves the established criterion.
- CRT** An abbreviation for Cathode Ray Tube—an output device that displays characters or graphics via electrically stimulated phosphorescence on a glass surface. The screen of an ordinary television set is an example of a CRT.
- CURSOR** A symbol placed on the screen to let the user know where the next typed character will appear.
- CYBERNETICS** The field of technology involved in the comparative study of the control and intracommunication of information in man and machine.
- DATA** A representation, such as characters, to which meaning might be assigned; for example, a representation of information expressed in printed form.
- DATA BASE** A collection of data fundamental to an operation organized in some predefined structure.
- DATA PROCESSING** Any operation or combination of operations on data, usually in accordance with a specified or implied set of rules, as a series of discrete steps, including operations such as compute, assemble, compile, interpret, generate, translate, store, retrieve, transfer, select, extract, shift, search, sort, merge, transliterate, read, write, print, erase, punch, etc.
- DATA PROCESSING, CENTRALIZED** The processing of all data pertaining to a given activity at a single location, usually with a given configuration of equipment in one building.
- DATA PROCESSING, DECENTRALIZED** The processing of data within each subdivision of an organization or at each geographical location of the parts of an organization. Contrast with data processing, centralized.
- DEBUG** To search for and correct errors in a computer program.
- DIGITAL COMPUTER** A computer that processes information in the form of binary coded signals. The five functional parts of all digital computers are the control unit, the memory, the arithmetic unit, the input unit, and the output unit.

- DRILL AND PRACTICE** Instructional material presented in a repeated fashion. Computer serves as a drill master and record keeper.
- ERASE** To remove data from storage, leaving the remaining space in a blank condition.
- EXTERNAL MEMORY** A storage unit which is external to the computer (e.g., magnetic tapes, magnetic disks, and punched cards).
- FILE** An orderly, self-contained collection of data that is usually stored on a permanent storage device such as a disk. Although files are not part of programs, they can be accessed for use in any program.
- FLOATING POINT** A form of number representation in which quantities are represented by a number multiplied by the number base raised to a power. A computer that has built-in circuitry for automatically controlling the location of the decimal or binary point called floating-point computer.
- FLOPPY DISK** A mass storage device that uses a magnetically coated flexible platter (disk) to store large quantities of information cheaper than hard disks.
- FLOWCHART** A graphical representation for the definition, analysis, or solution of a problem, in which symbols are used to represent operations, data, flow, and equipment.
- FORTRAN (FORMULA TRANSLATOR)** A widely used language that translates statements expressed in a format similar to algebraic equations into computer language.
- GARBAGE** Unwanted and meaningless information in the memory of a computer.
- GENERAL PURPOSE COMPUTER** A computer designed to solve a large variety of problems.
- GRAPHICS** A computer has graphics ability if it is able to display pictures or drawings.
- GRAPHICS TABLET** An image input device that allows the user to enter pictorial information directly into the computer by sketching or tracing any shape or series of shapes on the tablet surface.
- HARD DISK** A mass storage device that uses a disk with magnetic coating which is not flexible and much larger than a floppy disk to store a tremendous amount of information (up to 600 million bytes).
- HARDWARE** A term used to describe the mechanical, electrical, and electronic elements of a data processing system.
- INDIVIDUALIZED INSTRUCTION** Adapting instruction to individual requirements, providing for self-directed learning, self-pacing, independent study, and one-to-one teaching.
- INFORMATION** The meaning assigned to data by known conventions. Thus, data are the marks, such as characters, signs, or symbols themselves, whereas the knowledge assigned to them is information.
- INPUT** The data to be processed. The device or collective set of devices used for bringing data into another device. A channel for impressing a state on a device or logic element. The process of transferring data from an external storage to an internal storage.
- INPUT-OUTPUT DEVICE** A unit that accepts new data, sends them into the computer for processing, receives the results, and converts them into a readable form.
- INSTRUCTIONS** A set of characters (normally consisting of a command) which, when interpreted by the control unit, causes a data processing system to perform one of its operations.

- INTEGER** A complete entity, a whole number—not fractional or decimal.
- INTERFACE** A device or a program that allows two different parts of a system to “communicate” with each other.
- INTERPRETER** A computer program that translates and executes each source language instruction before translating and executing the next one.
- INTERRUPT** A break in the normal flow in such a way that it can be resumed from the point of interruption.
- ITERATIVE PROCESS** A method of solving a problem by repeating a series of steps until the solution or a good approximation of it has been achieved.
- JOYSTICK** A device that employs a swivel-type movement in order to control microcomputer graphics. It transforms mechanical variations into proportional changes in electric current which ultimately creates a displacement of a cursor on a CRT.
- JUMP** To transfer program control to some statement other than the next consecutive instruction.
- KEYBOARD** A set or panel consisting of an array of keys. Depressing a key causes the input of the specific character or symbol printed on the key.
- KEYPUNCH** A keyboard-actuated device that punches holes in a card to represent data.
- KEYPUNCHING** Transcribing alphabetical or numerical information into card by manual keyboard punching of the data.
- LANGUAGE** A set of representations, conventions, and rules used to convey information.
- LATENCY** The time from the display of an instructional stimulus to the start of the student’s response.
- LIBRARY** A collection of organized information used for study and reference.
- LIGHT PEN** An optical scanner that recognizes patterns of light and dark. Light pens are used with a CRT screen to add, modify, or delete information.
- LINE PRINTER** A printer in which an entire line of characters is composed and prepared for printout within the device prior to its printing, thus enabling the whole line to be printed nearly simultaneously.
- LISTING** A printout or display of the statements of a computer program.
- LOAD** To input information into the storage of a digital computer.
- LOG-IN/LOG-OUT** The procedure by which a user initiates or ends a session on a time-sharing system.
- LOOP** A closed path or any sequence of events that repeats itself, is closed back on itself, or connected back on itself.
- LSI** An abbreviation for Large Scale Integration—LSI refers to the process of manufacturing large numbers of microminiature electronic components on very small pieces (“chips”) of semiconductor material.
- MACHINE LANGUAGE** A language that is used directly by a machine. It is a set of symbols, characters, or signs, and the rules for combining them, that convey instructions and information to a computer. Program steps and data are expressed in binary code that can be read directly and used by the computer without further translation.
- MAINTENANCE** Activity intended to keep equipment (hardware) or programs (software) in satisfactory working condition, including tests, measurements, replacements, adjustments, repairs, program copying, and program improvement. Maintenance is either preventive or corrective.

MASS STORAGE Refers to large volume storage, on-line, and directly accessible to the central processing, arithmetic, logic, or control unit of a computer, usually magnetic disks or tapes.

MICROCOMPUTER A small computer system whose central processing unit (the part of the machine that can automatically carry out the instructions in a program) consists of a single chip or a small number of chips.

MICROPROCESSOR A single chip which contains the electronic circuitry necessary for digital arithmetic and logical operations.

MODEM An abbreviation of the words MOdulator-DEModulator. A device which enables data to be transmitted over telephone lines.

NANOSECOND A billionth of a second. A time measurement used to measure the operating speed of a computer.

NETWORK An interconnected set of points or objects, such as electrical circuit elements, power stations, communications equipment, or terminals.

NOTATION A systematic or conventional method for representing information through the use of signs and symbols, such as numerals, alphabetic characters, and special signs, and most commonly applied to number systems.

OBJECT PROGRAM The language or set of coded instructions into which a source language is translated by means of a compiler. Usually, object language and machine language are the same.

OFF-LINE Pertains to operating devices not under the direct control of the central processing unit.

ON-LINE Pertains to operating devices under the direct control of the central processing unit. An example of an on-line device is the printer that operates only under the control of the central processing unit.

OPERATING SYSTEM Software which controls the execution of computer programs, an organized collection of techniques and procedures for operating a computer.

OPTICAL SCANNER 1. A device that scans optically and usually generates an analog or digital signal. 2. A device that optically scans printed or written data and generates their digital representations. 3. Synonymous with Visual Scanner.

OUTPUT Information transferred from internal storage to output devices to produce output cards, tapes, business forms, and so forth.

PACKAGE (SOFTWARE) A computer application designed for a particular purpose. It may require modification by the user.

PASCAL (LANGUAGE) A high-level, machine independent language named after Pascal, a seventeenth-century philosopher and mathematician.

PERIPHERAL EQUIPMENT Units or devices that are part of an entire data processing system, but not actually part of a computer, i.e., an automatic typewriter functioning off-line, card sorter, reproducer, a forms burster, forms encoder, and so forth.

PLOTTER A device used in conjunction with a computer to plot coordinate points in the form of a graph.

PRINTER An output device for printing out the results of data processing.

PROCESS CONTROL (BY COMPUTERS) Pertains to control of industrial processes to provide automation or continuous operation.

PROGRAM The set of instructions given to a computer in order to solve a problem.

PROGRAMMER A person who writes and documents computer programs.

PROGRAMMED INSTRUCTION Teaching that uses a step-by-step method of presenting basic elements of subject matter to a student. Programmed instruction usually alters the course of instruction depending upon the results of part instructions (branching).

PROM "Programmable Read Only Memory"—an internal memory device that can be permanently programmed by a computer user.

PROMPT A symbol that appears on the screen to let the user know that the computer is ready to pay attention to commands.

PUNCH 1. A device that will make holes to represent information in any medium in accordance with signals sent to it from another source, such as a computer, a communication link, or a human being through a keyboard. 2. A hole in a data carrier or medium, such as tape, cards, or sheets of paper, usually made in arrays with other holes to represent information.

PUNCH CARD 1. A card punched with a pattern of holes to represent data. 2. A card as in (1) before being punched.

PUNCHED TAPE A tape on which a pattern of holes or cuts is used to represent data.

RAM An acronym for Random Access Memory—a memory device that is used for temporary storage of information placed into the computer by the user. It is volatile storage in that the information placed in RAM is often lost when power to the computer is shut off.

RECORD A physical division of a file usually consisting of a number of interrelated data elements.

REGISTER A device inside the CPU that stores a specified amount of data and is capable of rapid transfer of that data.

REAL-TIME A method of processing data fast enough so that the time between inquiry and result is less than a value given in advance.

REMEDIATION Instructional action taken because a learner has made an inappropriate response. Remediation decreases the likelihood of the inappropriate response.

ROM "Read Only Memory" computer can read from memory but cannot write new information into it. It is unchangeable memory.

SIMULATE To represent or model the functioning of one system by another, for example, to represent one computer by another, to represent a physical system by the execution of a computer program, to represent a biological system by a mathematical model.

SIMULATION The representation of real systems and phenomena by computers, in which the processing done by the computer represents the process itself.

SOFTWARE The collection of programs and routines associated with a computer, for example, compilers, library routines. Software refers to the internal programs or routines professionally prepared to simplify programming and computer operations. These routines permit the programmer to use something close to his own language in communication with the computer. Software usually provided by manufacturers includes various assemblers, generators, subroutine libraries, compilers, operating systems, and application programs.

SOURCE PROGRAM A program written in a source language such as FORTRAN, COBOL, BASIC, or Pascal.

STORAGE 1. Pertaining to a device into which data can be entered, in which they can be held, and from which they can be retrieved at a later time. 2. Loosely, any device that can store data. 3. Synonymous with Memory.

STRING A sequence of alphanumeric characters.

SUBROUTINE A routine that is part of another routine; a set of instructions set aside as a whole in a particular part of storage locations to be called each time it is to be executed.

SYNCHRONOUS A mode of operation such that the execution of each instruction or each event is stepwise controlled by a clock signal. Contrast with asynchronous.

SYSTEM An organized collection of parts or elements, such as men, machines, methods, and information, united by regulated interaction and designed or required to accomplish a specific purpose or reach a specific purpose or reach a specific objective. See Operating System.

TAPE In computers and data processing, a linear storage medium. The tape may be reeled, spooled, or spindled; used as input, output, internal, or external storage; and is usually magnetic and sometimes paper.

TELETYPEWRITER American Telephone and Telegraph terminal equipment that permits sending by a manual keyboard and receiving on a printed page, much like an electric typewriter, except that it encodes the characters for long-distance transmission, and decodes incoming signals into printed characters.

TERMINAL A device by which data can be sent to or received from a computer system; for example, a cathode ray tube display (similar to a television screen) or a teletypewriter.

TIME SHARING The use of a single processing unit in which users simultaneously share the available processing time.

TRANSLATE To convert data from one language to another language without affecting the meaning.

TRANSMIT To move data from one location to another location, such as by reading or sensing the data at the source, moving them over a communication channel, and storing them at the destination.

UNCONDITIONAL BRANCH or UNCONDITIONAL TRANSFER A branch (or jump out of the normal execution sequence in a program) which is executed regardless of conditions.

UNIT RECORD EQUIPMENT Preparation materials, such as keypunch machines, card readers; separated from computer itself.

UP-TIME Time during which a machine is available for use or is used and is not known to be malfunctioning.

VALIDITY A measure of the extent to which a standard has been met or a rule followed.

VARIABLE The representation of a quantity, or the quantity itself, which can assume any of a given set of values. In most equations, or other mathematical expressions, the quantities involved are represented with symbols, and either the quantities themselves or the symbols are considered as variables.

WORD In computers and information processing, a group of characters treated as a unit and to which meaning can be assigned. A sequence or group of characters, such as bits, treated as a unit and capable of being stored in one computer storage location.

WORD PROCESSING SYSTEM A system providing the capability of editing and formatting text quickly and efficiently.

WRITE To deliver data to a storage medium; that is, to record data; for example, to place data on a magnetic tape; to punch data on cards in the form of a pattern of holes; to place data in core storage, or drums, or disks; to place marks on a mark-sensed card; or to draw patterns on the screen of a cathode ray tube with a controlled beam of electrons, either for storage or for visual display.